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MATERIALS SCIENCE AND METALLURGY

No. 77

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ALUMINUM AND ITS ALLOYS

UDC 620.186.1:669.71

MECHANISM OF EFFECT OF SCANDIUM ON INCREASING STRENGTH AND THERMAL STABILITY OF ALUMINUM-MAGNESIUM ALLOYS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 2, 1981
(manuscript received 6 Nov 80) pp 353-356

DRITS, M. Ye., PAVLENKO, S. G., TOROPOVA, L. S., BYKOV, Yu. G. and BER, L. B., Institute of Metallurgy imeni A. A. Baykov, USSR Academy of Sciences, Moscow

[Abstract] The mechanism through which strengthening of aluminum-magnesium alloys upon addition of scandium occurs is analyzed on the basis of data on recrystallization in Al + 6.5% Mg alloys with 0-0.5 wt.% Sc. Specimens of these alloys were produced in an argon atmosphere in a laboratory induction furnace. After homogenization at 430°C for 24 hrs, each round ingot was split into two parts: one for pressing and drawing (to an index $\lambda = 9$), one for hot forging and cold rolling to a 2-mm thickness with intermediate anneals at 360°C. The recrystallization process was tracked under a Tesla BS-540 electron microscope in polarized light and also by x-radiography. Addition of scandium was found to raise the temperature of the beginning of recrystallization: 0.2 wt.% Sc raising it to 350°C for both pressed and rolled products, 0.5% wt.% Sc raising it by only 50°C more, and no complete recrystallization having been reached at all. This indicates that scandium produces a structure with thermal and time stability, the yield point of pressed products hardly changing with an increase of the annealing temperature. Some lowering of the yield point of rolled products after precrystallization annealing is attributable to recovery effects. Annealing at 450°C increases somewhat both the size of and the distance between particles of the $ScAl_3$ phase. An analysis of these effects suggests that secondary precipitates of the nonrecrystallized $ScAl_3$ phase produce an effective barrier to movement of dislocations, and that fine-disperse particles of this phase contribute directly to a hardening of the alloy. The article was presented by academician A. A. Bochvar on 1 Nov 80. Figures 2; references 11: 6 Russian, 5 Western.
[156-2415]

UDC 620.172.24:669.715

RESIDUAL STRENGTH AND CRACKING RESISTANCE OF ALUMINUM ALLOY

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 17, No 3, May-Jun 81 (manuscript received 21 Jul 80) pp 3-11

KISHKINA, S. I., STAROVA, Ye. N. and YAMILINETS, V. F.

[Abstract] A method of determining the stress intensity coefficient at the instant of cracking has been developed, for the purpose of establishing a reliable criterion of cracking resistance and fracture toughness in the case of semibrittle materials such as some aluminum alloys. Plate and strip specimens of verious thicknesses with crack simulating slits intentionally cut across the center are loaded in tension. The test data are evaluated in terms of a "normalized compliance--relative crack length" calibration curve, after approximation with a third-degree polynomial according to the method of least squares. Then "load--crack opening displacement" diagrams are plotted. Plate and strip specimens of several aluminum alloys (1201-T1, Ak41-T2, V95pch-T2, D16AT) formed by various processes (wrought-rolled, stamped-rolled, pressed, cold rolled) were thus tested in tension, with the force acting either through the center of the slit or off center. For thick plates (10-20 mm) the stress intensity coefficient ot the instant of cracking, based on a load allowing for a 2% increment of crack length, is found to almost coincide with the point of transition from linear to nonlinear cracking in the first case and to be much lower second case. The ratio of the stress intensity coefficient at brittle fracture is not a universal criterion for the load carrying capacity of panels with cracks, but the ratio of this coefficient during transition to instability to the coefficient calculated here is a more reliable criterion. It depends on the material as well as on the dimensions (width) of a panel. Figures 4; references 5: 2 Russian, 3 Western.
[157-2415]

UDC: 669.725:669.01/09

HYDROGEN PERMEABILITY OF BERYLLIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 81 (manuscript received 18 Oct 79) pp 73-77

AL'TOVSKIY, R. M, YEREMIN, A. A. [deceased], YEREMINA, L. F., IZHVANOV, L. A., FADEYEV, V. N., URAZBAYEV, M. I., Moscow

[Abstract] Hydrogen permeability was studied at pressures below 1 atm at temperatures of 500-650°C using pipes obtained from powdered (56 μm) hot extruded beryllium 98.4 wt.% pure (main impurity oxygen, 1.3 wt.%). The same material was also used to study the mechanical properties. The method of the study was based on periodic measurement of the pressure of gas penetrating through the wall of the beryllium pipe and accumulating at constant temperature. The ends of the pipes were sealed with epoxy resin after insertion of zirconium hydride designed to serve as a source of hydrogen and maintain the internal pressure constant at 300 mm Hg. A diagram of the experimental installation is presented. The activation energy of the process of penetration of hydrogen through the beryllium pipe was determined from the slope of the curve of pressure as a function of time to be 10.6 kcal/mol, comparable to the activation energy for iron and quartz, one-third of the energy for aluminum and tungsten. The mechanical properties of beryllium remained practically unchanged after exposure to hydrogen at 100 atm. abs., 400-700°C. The permeability of hot pressed beryllium decreases with a decrease in initial powder particle size. Figures 3; references 15: 7 Russian, 8 Western.
[144-6508]

UDC: 624.074:678.067

DEFORMATION OF COMPOSITE CYLINDRICAL SHELLS UNDER COMBINED DYNAMIC LOADING

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 81
(manuscript received 29 May 80) pp 461-473

BOGDANOVICH, A. Ye. and FELDMANE, E. G., Institute of Polymer Mechanics,
Latvian Academy of Sciences, Riga

[Abstract] A study is made of the process of deformation of a multilayered composite cylindrical shell loaded simultaneously with an axial dynamic compressive load and dynamic external pressure. Primary attention is given to analysis of the shape of the bulging surface of the shell with various relationships between the rates of application of the loads and to calculation of the variation of stress as a function of time at the points of most dangerous bulging. The study is based on methods of calculation and results outlined in an earlier work in which the problem of deformation of a cylindrical shell under the influence of an axial dynamic load or a dynamic external pressure was solved in its geometrically nonlinear statement. Factors are outlined which determine the selection of the optimal structure of a material with the type of loading in question anticipated. Various combinations of static and dynamic forces are also studied. Ranges of loading speeds in which stresses caused either by axial compression or external pressure predominate are studied. It is shown that preliminary static loading results in a significant change in the initial imperfections of the shape of a shell, which influences the subsequent process of dynamic bulging. A method of layer by layer analysis of the strength of a shell is developed for calculation of the moment of occurrence of the first defect and its location. The method utilizes a tensor-polynomial criterion for analysis. Figures 9; references 27: 23 Russian, 4 Western.
[164-6508]

UDC: 539.4

CREEP OF COMPOSITE MATERIAL IN RELATION TO PROPERTIES OF ITS COMPONENTS

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 81
(manuscript received 10 Dec 79) pp 64-68

GOKHBERG, Ya. A. and DANENKO, V. F., Volgograd Polytechnical Institute

[Abstract] Creation of new composite materials for use at elevated temperatures requires prediction of their relaxation properties based on the properties of their components. Construction of a creep curve for a composite material based on the known creep curves of its components could greatly expand the possibility of prediction of properties. Creep is a continuous process, the parameters of which at any moment in time are determined by the entire prehistory of the material and specifics of the processes of hardening and softening which are simultaneously occurring. The approach suggested for estimation of the accumulation of damage in the process of creep combines two theories of failure: the thermokinetic theory and the deformation theory. The calculation equations presented in this article satisfactorily describe the process of creep of monometallic and composite materials from the beginning of loading to the point of failure. These equations can if necessary be used to obtain a full creep curve and determine the rate of stable creep or the deformation accumulated during a given period of time, or the time over which a given amount of deformation will accumulate. Figures 4; references 14: all Russian.
[138-6508]

UDC: 539.4:678.067

INFLUENCE OF VARIOUS FACTORS ON VIBRATION CHARACTERISTICS OF GAS TURBINE MOTOR BLADES OF COMPOSITE MATERIALS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 81
(manuscript received 19 Apr 80) pp 486-493

KARTASHOV, G. G., Kuybyshev Aviation Institute

[Abstract] A study of cantilever mounted plates was performed with natural oscillations studied on the basis of the refined theory of multilayer anisotropic plates of glass-reinforced plastic, carbon-reinforced plastic and glass- and carbon-reinforced plastic. The great density of the natural oscillating frequency spectrum of composite turbine blades and the tendency toward development of coupled forms of oscillation make it increasingly difficult to tune composite turbine blades to avoid damaging natural oscillations in operation. It was assumed that the materials have a single plane of elastic symmetry and follow Hooke's law. Transverse shear, normal compression and rotational inertia effects were considered. It was assumed that there were no loads on the upper or lower planes of the plate. Layer slippage was also assumed to be zero. The

natural oscillating frequency was found to be quite dense with intersection of the frequency curves of various oscillating forms. This results in "play" of the forms, variation in the picture of nodal lines as a function of the point of excitation. The higher forms of oscillation have the greatest tendency toward interaction with other forms. The theory proposed, which considers only transverse shear, yields good approximation of experimental results, with a deviation of natural oscillating frequencies of 1-5%. It is found that an increase in the angle of reinforcement of a high-modulus layer may result in a decrease in the frequencies of torsional forms of oscillation, particularly for plates with relatively short span. Figures 5; references 8: 7 Russian, 1 Western.
[164-6508]

UDC: 539.3.677

THERMAL STABILITY OF MECHANICAL PROPERTIES OF CARBON FIBERS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 81 (manuscript received 20 Mar 80) pp 547-549

KOBETS, L. P., MOSTOVOY, G. Ye. and TIMOSHINA, L. N., Moscow

[Abstract] An estimate is presented of the influence of temperature on the value of E_0 and σ_0, and the temperature of variation of the stress concentration factors in carbon fibers is refined, both for internal and for surface defects. The study involved tensile testing at 20-1900°C in a vacuum, plus statistical processing of the data of earlier studies. The stress concentration factor in carbon fiber shows a clear tendency to decrease with increasing test temperature. However, the strengthening of the fiber which would be expected on this basis does not occur due to the catastrophic reduction in the maximum achievable strength upon heating. Figures 2; references 5: all Russian.
[164-6508]

UDC 669.018.44:539.389.2

EFFECT OF CARBON, BORON AND IRON ON HEAT RESISTANCE AT 1100°C OF NICKEL ALLOYS FOR MATRIX OF COMPOSITE MATERIALS WITH FIBER REINFORCEMENT

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81 (manuscript received 21 Jun 79) pp 155-156

DORONIN, I. V., CHERNUKHA, A. I., ZORINA, M. K., TRUNIN, V. F. and MAKARENKO, V. I., Moscow

[Abstract] A study was made to determine the effect of carbon, boron and iron on the strength (0.1 to 1000 hrs) at 1100°C of nickel alloys used as the matrix of composite materials with fiber reinforcement. Four laboratory grades (Kh20N80 with 0.05% C and with 0.19% C, NM27F with 0.08% C and with 0.15% C)

were produced in a 20 kg induction furnace. Also six industrial GOST 5632-72 grades (KhN67VMTYu with 0.74% Fe, KhN57MTVYu with 9.4% Fe, KhN55MVYu with 19.5% Fe, KhN77TYuP with 0.006% B, KhN77TYuP with 0.007% B, KhN77TYu without boron) were tested. The results indicate that carbon in Kh20N80 and NM27F alloys increases their short-term (before 1 hr) and decreases their long-term (after 10 hrs) heat resistance, evidently due to the formation of $M_{23}C_6$ and M_6C carbides. These carbides initially inhibit grain growth and later stimulate depletion of refractive alloying elements (Cr, Mo) in the solid solution. The increase of the iron content in the KhN67VMTYu-KhN57MTVYu-KhN55MVYu series decreases, in the same order, the long-term heat resistance by causing fracture after 812, 415, and 165 hrs respectively under a stress of 11 MPa and after 0.1 hr of all three alloys under a stress of 60 MPa. The test results for KhN77TYu and KhN77TYuP alloys, differing in the boron content only, reveal no favorable effect of boron on the long-term heat resistance at 1100°C. On the contrary, boron shortens the time till fracture under any stress from 11 to 50 MPa. References 4: all Russian.
[154-2415]

UDC 539.216.1+539.67:6208

STRUCTURAL INSTABILITY AND DAMPING CHARACTERISTICS OF AN ALUMINUM-BORON COMPOSITE

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81
(manuscript received 21 Apr 79) pp 130-133

POSTNIKOV, V. S., AMMER, S. A. and KACHEVSKIY, A. N., Voronezh

[Abstract] The structural instability and the damping characteristics of the Al + 45% B (fiber) composite were studied by the highly sensitive method of internal friction. Sheet of aluminum foil with unidirectionally laid reinforcing boron fibers was produced by the diffusion sintering process, and 100-mm-long 1 x 1 mm square wire specimens cut from it by the electric-spark method were tested in a torsion pendulum. The temperature dependence of the recovery of internal friction $Q^{-1}(T)$ was measured over the 20-500°C range and the dependence of this recovery on the amplitude of shear strain $Q^{-1}(\varepsilon)$ over the $\varepsilon = (1\text{-}30)\cdot10^{-5}$ range was measured at 50°C intervals, with the pendulum oscillating at a frequency of approximately 1 Hz. The specimens were also subjected to heating-cooling cycles: heating to 500°C - holding - cooling at 10°C/min to 100, 150, 200°C for isothermal annealing. An analysis of the results indicates that the hysteresis of $Q^{-1}(T)$ is due to the difference between the thermal expansivities of boron and aluminum, and that temperatures within the 300-350°C range are critical with respect to structural instability due to thermal stresses, especially residual ones as well as due to buildup of defects at the fiber-matrix boundary. A simple relation between the relaxation characteristic $Q^{-1}(f_n,T)$ of the material and that of its components is proposed on the basis of which the damping characteristics of the material can be predicted and the composition of the material can be optimized. The authors thank M. Kh. Shorshorov and V. V. Belov for the helpful discussion. Figures 3; references 9: 6 Russian, 3 Western.
[154-2415]

UDC 539.4

PREDICTING STRENGTH CHARACTERISTICS OF COMPOSITE MATERIALS BY COMPUTER SIMULATION OF FRACTURE MECHANISMS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81 (manuscript received 26 Sep 80) pp 122-129

OVCHINSKIY, A. S., BILSAGAYEV, N. K. and KOP'YEV, I. M., Moscow

[Abstract] For the purpose of designig the structure and predicting the strength of composite materials on the basis of fracture macromechanisms, four fracture micromechanisms and their interaction have been simulated in the FORTRAN-4 language on a BESM-6 high-speed digital computer. These micromechanisms include primary events (fracture of fibers) and three kinds of secondary events (peeling of broken fibers from the matrix, fracture of the matrix at fiber discontinuities, fracture of fibers due to overloading). The simulation is based on a subdivision of the composite material into microvolumes of minimum critical dimensions and on a stress analysis over some section. The model contains deterministic quantities (volume fraction of fibers, force of friction between fibers and matrix, parameters of their stress-strain diagrams) and statistical quantities (mean strength of fibers and matrix, shear strength of fibers, matrix, and binder, respective variances, variance of the distance between fibers, scale effects characterizing the distribution of strength between short fiber segments and local matrix masses. The results of this simulation, according to the AKTIV 3.1 program, agree closely with experimental data and can thus serve as a rough basis for optimizing the ratio of fiber and matrix strength to binder strength. Figures 5; references 7: all Russian.
[154-2415]

UDC: 624.073:539.4:678.067

NATURAL OSCILLATIONS OF FLAT AND SPHERICAL THREE-LAYERED TRAPEZOIDAL PANELS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 2, Mar-Apr 81 (manuscript received 25 Mar 80) pp 238-243

SHALASHILIN, V. I., KOLESNIKOV, I. Yu., LOZHKIN, O. B. and NAGAYEV, V. A., Moscow Aviation Institute imeni S. Ordzhonikidze

[Abstract] A study is made of the problem of natural oscillations of three-layer trapezoidal flat and spherical panels with honeycomb filler, freely suspended around the edges. A theoretical solution is constructed on the basis of the theory of smooth three-layer shells with transversely isotropic filler. The parameters of the filler are determined on the basis of the parameters of a discrete honeycomb filler, extended to the continuous filler here used. The results of the experiments performed for rectangular panels with honeycomb filler made of glass-reinforced plastic are compared with the theoretical results. A membrane analogy is used to determine the natural oscillating

frequencies for polygonal flat and spherical panels. The problem of the natural oscillations of a trapezoidal membrane is solved by two methods, the method of perturbations in the quadratic approximation and the method of straight lines. The influence of the basic parameters of the three-layer panels on the fundamental oscillating frequency is determined for the practical range of possible variations. Figures 5; references 11: all Russian.
[163-6508]

UDC: 539.3:678.5.06:624.073

ONE PROBLEM IN OPTIMIZING PLATES MADE OF COMPOSITE MATERIAL

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 2, Mar-Apr 81
(manuscript received 11 Mar 80) pp 244-248

SHAMIYEV, F. G., Institute of Mechanics and Mathematics, Azerbaijan Academy of Sciences, Baku

[Abstract] A study is made of the problem of optimization of circular, freely supported plates of a composite material exposed to a uniformly distributed transverse load. It is considered that the composite consists of an ideally plastic matrix with different yield points in extension and compression, reinforced in two perpendicular directions, in each direction in one layer with stronger, ideally rigid-plastic fibers with different strengths in extension and compression, different in each direction. The goal functional minimized expresses the total number of fibers and is composed based on the known flow condition for analogous plates. The condition of optimality is derived and it is demonstrated that for the plate in question the central circular area must be reinforced in both the radial and circumferential directions, while the ring-shaped outer area adjacent to the contour need be reinforced only in the circumferential direction. The rules of change of the quantity of reinforcement and the corresponding field of bending rates are determined. Figures 3; references 8: 3 Russian, 5 Western.
[163-6508]

UDC: 539.4:678.067:621.642

ESTIMATE OF STRESS-STRAIN AND LIMIT STATES OF COMBINED CYLINDERS UNDER INTERNAL PRESSURE

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 2, Mar-Apr 81
(manuscript received 9 Apr 80) pp 262-266

ZAYTSEV, G. P., VASILEVSKIY, V. M., GOLLANDTSEV, A. V. and KOPYL, N. I.,
Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy

[Abstract] An experimental and calculation method is used to study the stress-strain and limit states of combined cylinders. Each cylinder consists of a cylindrical shell 250 mm in diameter with a hemispherical cap at each end with a volume of 0.012 m^3. The cylinder consists of an internal ceiling portion made of high strength type EP stainless steel and an external shell consisting of eight layers of epoxy glass-reinforced plastic with a total thickness of 2.2 mm. The outer shell was manufactured by 2-zone winding of presaturated glass tape at angles of 12 and 19° onto the cylinder by means of a program-controlled winding machine. Various combinations of thickness of the metal cylinder and end caps were studied. It was found that the cylinders failed in a sequential manner: first the metal shell failed, then the glass-reinforced plastic shell failed, and in no cases of failure were fragments formed. The use of the glass-reinforced plastic reinforcement increased the pressure at failure by an average of 35-40%, improving the weight to strength ratio by 12 to 15%. Figures 4; references 5: all Russian.
[163-6508]

UDC: 539.21:539.4:678.067

INFLUENCE OF REPEATED HEATING CYCLES ON MODULUS OF ELASTICITY OF CARBON-BASED MATERIALS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 2, Mar-Apr 81
(manuscript received 2 Jun 80) pp 273-276

PISARENKO, G. S. and SKVORTSOVA, N. V., Institute of Strength Problems,
Ukrainian Academy of Sciences, Kiev

[Abstract] Results are presented from experiments with specimens of a carbon-based material reinforced with carbon fibers twisted into cords and laid in unidirectional alternating layers rotated with respect to each other by 30°. A phenol resin was used as the binder. After pressing, the plates were pyrolyzed and then carbonized from the gas phase and cut into specimens. Some of the specimens thus produced were saturated with liquid silicon carbide. Young's modulus was determined by a dynamic method using a cantilever mounted rod-shaped specimen based on the resonant frequency of transverse oscillations. The

specimens were heated at 100°C/min from 20 to 900°C in a resistance furnace in air. After 900°C was reached, the current in the furnace was cut off and the specimens cooled together with the furnace. They were then weighed and measured and returned to the furnace for the next heating cycle. Nine to 10 such 35 to 40 minute cycles were performed for each specimen. The nature of the curves $E = F(T)$ for the first two heating cycles was the same for both types of specimen, the additional siliciding of the material having no qualitative influence on the course of the curve. However, quantitative differences were observed. The decrease in Young's modulus upon cyclical heating is greater for the silicided specimens. Figures 3; references 2: both Russian.
[163-6508]

CONFERENCES

FIRST ALL-UNION CONFERENCE ON MULTILAYER WELDED STRUCTURES AND PIPES

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, Jul 81 pp 60-62

GOL'DENBERG, A. A.

[Abstract] The First All-Union Conference on Multilayer Welded Structures and Pipes was held in Kiev 17 through 21 November 1980. Some 400 specialists from 31 cities of the USSR took part in the conference, organized by the State Committee on Science and Technology, the Ukrainian Academy of Sciences and several institutes. There were three sections at the conference: 1. strength and stress-strain state of welded structures and pipes; 2. multilayer welded structures; and 3. multilayer pipes. Sixty-three reports were heard, with primary attention given to the prospects for development and improvement of technologies for the manufacture of multilayer structures and pipes, the study of new steels and their heat treatment, the study of the strength properties of multilayer walls under various operating conditions and problems of expansion of the areas of their application. It was particularly noted in the resolution adopted by the conference that performance of theoretical and experimental studies and the accumulated experience in the manufacture and operation of multilayer steel structures and pipes provide a basis for expanding the area of application of complex apparatus and parts with multilayer walls. However, there are a number of unsolved problems, such as the unsatisfactory rate of introduction of multilayer structures to power engineering machine building, the lack of a coordinated program for such operations, the failure to fulfill assignments of the State Scientific and Technical Committee for the manufacture of certain structures of multilayer materials and the creation of sections at machine building enterprises for the manufacture of welded multilayer equipment. The works of the conference are to be published by the Naukova Dumka Press in 1982. The Second All-Union Conference is planned for 1985.
[147-6508]

UDC 620.194.2

CORROSION BEHAVIOR PECULIARITIES OF Al-Zn-Mg ALLOYS DURING TESTS UNDER ATMOSPHERIC CONDITIONS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 17, No 3, May-Jun 81 (manuscript received 23 Dec 79) pp 38-42

KALININ, V. D., SINYAVSKIY, V. S. and IVANENKO, N. I.

[Abstract] The corrosion behavior of some Al-Zn-Mg alloys (V92, ATsM, 1915, V95) is analyzed on the basis of experimental data on cracking of 1-6-mm-thick specimens in the semifinished product state over periods of 1 to 10 years. The V92 and ATsM alloys were found to be the most susceptible to pitting under almost any conditions, the crack length after 10 years ranging from 1.5 mm in a warm (100-160°C) storage room to 3 mm in the atmosphere of southern seashores and 27 mm in the atmosphere of northern seashores. This mode of stress-corrosion cracking is definitely ralated to parting corrosion, both processes simultaneously affecting a product with a low resistance to vertical cracking, particularly in the aggressive atmosphere of sea air. These as well as 1915 alloys are not susceptible to intercrystalline corrosion, only to transcrystalline corrosion. With respect to stress-corrosion cracking in sea air, moreover, the stress intensity coefficient at the instant of cracking is much higher for 1915 than for all the other three types of alloys. Figures 4; references 8: 6 Russian, 2 Western.
[157-2415]

UDC 620.198

NICKEL-ALUMINUM COATING FOR PROTECTION OF HEAT-RESISTANT TITANIUM ALLOY AGAINST STRESS-CORROSION CRACKING UNDER FILM OF DRY CHLORIDE

Moscow ZASHCHITA METALLOV in Russian Vol 17, No 2, Mar-Apr 81
(manuscript received 10 Jan 80, after completion 19 May 80) pp 217-219

ANDREYEV, Yu. Ya., PERTSINA, Ye. L., KOBZEVA, N. P. and ISAYEV, N. I.,
Moscow Institute of Steel and Alloys

[Abstract] Nickel-aluminum coatings were used experimentally for protection of the VT18U titanium alloy against stress-corrosion cracking under a NaCl film at temperatures above 300°C. First a 10-30 μm-thick nickel layer was deposited by electrolysis of a sulfate. Then the specimens were calorized by the galvano-diffusion process from a salt melt, with the possibility of controlling the calorization rate and the aluminum content in the diffusional coating. Metallographic, x-ray spectral and x-ray phase analyses revealed either solid solutions of aluminum (up to 4%) and nickel or nickel aluminides (25-30% Al) in the coatings. Such coatings were found to provide a very effective protection, owing to their high long-term heat resistance up to 600°C. Another favorable factor are compressive stresses produced by the increase of the molar volume of the surface layer during the coating process. The nickel sublayer relaxes stresses at the coating-base boundary and provides a barrier to diffusion of aluminum to the titanium base, while Ti-Ni intermetallic compounds ensure a strong bond between nickel and the titanium base. Figures 1; references 7: 5 Russian, 2 Western.
[161-2415]

UDC: 539.432+620.178.3+620.194.8+620.197+621.438+621.515

INFLUENCE OF CATHODIC PROTECTION ON CYCLICAL STRENGTH AND CRACK RESISTANCE OF STAINLESS STEELS AND VT3-1 ALLOY IN CORROSIVE MEDIA

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 81
(manuscript received 29 Apr 80) pp 7-11

TROSHCHENKO, V. T., PROKOPENKO, A. V. and TORGOV, V. N., Institute of Strength Problems, Ukrainian Academy of Sciences, Kiev

[Abstract] The presence of an electrically conductive film consisting of a salt solution on the blades of gas turbines used in corrosive atmospheres containing seawater mist allows cathodic protection to be used for these blades. Protection with a sacrificial anode of magnesium or aluminum is preferrable to ordinary cathodic protection. Ships to be used in seas with relatively low salinity utilize short-circuited magnesium protectors which are quite effective. However, in certain cases cathodic polarization may result in hydrogen embrittlement of aluminum and steel blades, reducing the corrosion-fatigue strength of the materials. This article reports on a test of the influence of a magnesium

protector on crack resistance during cyclical loading of 20Kh13, Kh17N2, 1Kh12N2VMF and A stainless steels and VT3-1 titanium alloy in a seawater solution. The use of the sacrificial protector anode increased the endurance limit of 20Kh13 and A steels by 25 and 20%, though the fatigue strength was still lower than for the same metals in air. Figures 3; references 17: 11 Russian, 6 Western.
[138-6508]

UDC 620.193.27:669.14

INHIBITING STEEL CORROSION IN STREAM OF HOT SEA WATER BY CALCIUM AND MAGNESIUM CATIONS

Moscow ZASHCHITA METALLOV in Russian Vol 17, No 2, Mar-Apr 81
(manuscript received 13 Dec 79, after completion 19 Mar 80) pp 184-188

LEBEDEV, A. N. and DERBYSHEV, A. S., Sverdlovsk Scientific Research Institute of Chemical Machinery

[Abstract] A study was made of the inhibiting effect of Ca^{2+} and Mg^{2+} cations on corrosion of carbon steel in a stream of Caspian sea water at temperatures from 50 to 90°C. The sea water was simulated by an artificial preparation of water distillate continaing 4.76 g/l Na_2SO_4 + 4.26 g/l NaCl + 0.3 g/l $NaHCO_3$ + 0.03 g/l Na_2CO_3 + 0.97 g/l $CaCl_2$ + 6.58 g/l $MgCl_2$ + 0.13 g/l KCl. Tubular specimens of grade-20 and St3 steel were tested in a titanium vessel with a heater and a pump, the latter circulating the solution at velocities from 0.5 to 2 m/sec. Also disk specimens of St3 steel were tested, to simulate the conditions in the circulator with tubular specimens, these disks rotating at speeds from 560 to 4100 rpm. Potentiokinetic polarization curves were plotted on these disks, in the artificial sea water as well as in an aqueous 0.15 mole/l NaCl solution containing the same amount of the Cl^- anion. Stirring by rotation was found to increase the inhibiting effectiveness of Ca^{2+} and Mg^{2+} cations in a chloride solution, the corrosion rate of steel in sea water being determined by the diffusion stage of the process at all stream velocities and disk speeds. The test results reveal a decisive role of $CaCO_3$ and $Mg(OH)_2$ films in inhibiting the diffusion of oxygen to steel and passivating the surface of the latter. The results should be useful for the design and operation of distillation plants at the Caspian seashore. Figures 3; references 6: 5 Russian, 1 German.
[161-2415]

FERROUS METALLURGY

ACCOMPLISHMENTS OF THE FERROUS METALLURGICAL INDUSTRY

Moscow AGITATOR in Russian No 13, Jul 81 pp 31-33

[Article by A. Kazanets, USSR minister of ferrous metallurgy: "Metallurgical Workers on the March in the Five-Year Plan"]

[Text] The historic resolutions of the 26th CPSU Congress open up new and inspiring prospects for building communism and strengthening the resolve of urban and rural working people successfully to accomplish the designated program of further economic and social development of our homeland.

A significant contribution toward the upsurge of our nation's economy has been made and is continuing to be made by ferrous metallurgy -- the basic branch of heavy industry, which supplies metal products to practically the entire economy. For a number of years now the Soviet Union has been the world leader in production of ferrous metals. Today one out of every five tons of pig iron and steel produced in the world is produced in the USSR.

Soviet ferrous metallurgy has vast capacity. In the last decade the total value of the fixed productive assets of this industry has more than doubled. Pig iron production has increased by 21 million tons, steel production by 32 million, production of finished rolled stock by 22 million, and steel pipe by 5.8 million tons. The enterprises of Minchermet [Ministry of Ferrous Metallurgy] have almost doubled the output of consumer goods.

Much has been done to bring new products into production, to ensure the priority growth of manufacture of short-supply and economical metal products, to expand the variety and improve the quality of rolled stock, pipe and general metal products.

The past five-year plan was characterized by a further rise in the technological level of ferrous metallurgy. A large quantity of high-output metallurgical equipment, corresponding to the latest advances in science and technology, has been brought on-stream. At the Novolipetskiy Metallurgical Plant, for example, the 2000 mill has gone into operation, which can continuously cold-roll strip 0.5-3.5 mm in thickness at a rate of more than 30 meters per second. There are only three such mills in the world.

Growth and development of this branch has proceeded in concert with execution of an extensive program of housing and social-cultural facilities construction. Sanatoria-preventive clinics with accommodations for 4500 persons, rest houses accommodating 3400, general outpatient clinics accommodating 16,000 visits, hospitals totaling 6600 beds, children's preschool facilities accommodating 48,000, general-curriculum schools accommodating 53,000, vocational schools accommodating 19,000, clubhouses and recreation centers accommodating 13,000 were built for metallurgical workers in the 10th Five-Year Plan. More than 11 million square meters of housing was completed for tenancy.

It would be incorrect, however, to fail to see deficiencies and errors of omission behind these achievements. The CPSU Central Committee has pointed out these shortcomings, and we are presently working hard to correct them. The objective is to furnish the economy with greater quantities of economical metal products, rolled stock of low-alloy steel, heat-treatment hardened rolled stock, and sheet with anti-corrosion coatings.

Nonfulfillment of capital construction plans is occurring in this branch, and schedules for bringing equipment on-stream are not being met. Facilities coming on-stream are being brought up to capacity too slowly, and existing facilities are not being utilized to full capacity. Errors in production management and organization are occurring at some large enterprises, and scientific and technological advances are being little utilized.

The earliest possible correction of these deficiencies is particularly essential since the branch has been assigned complex tasks in the 11th Five-Year Plan, accomplishment of which will demand considerable effort on the part of all people in the ferrous metallurgical industry without exception.

The Principal Directions of Economic and Social Development of the USSR, ratified by the 26th CPSU Congress, call for boosting output of finished rolled stock in the final year of the 11th Five-Year Plan to 117-120 million tons, that is, to achieve a growth of 14-17 percent above the 1980 figure. Steel and pig iron production should correspondingly increase.

Obviously in order to achieve such a metal output growth it is necessary to bring additional facilities on-stream, to renovate existing and build new shops and equipment, as well as significantly improve the operations of existing facilities. It will also be necessary to increase production of merchantable iron ore by 10 percent. This increase is to be achieved through further development of existing as well as construction of new large mining enterprises: the first unit of the Stoylenskiy Mining and Concentration Combine in the Kursk Magnetic Anomaly basin, the Kostomukshskiy Combine in Karelia, the Kachirskiy Combine in Kazakhstan, the Krivoy Rog Combine, processing oxidized quartzites, plus others.

As regards additional facilities for the production of high-quality metal, we should mention first and foremost the Oskol Electrometallurgical Combine, which is under construction. It will become the world's largest enterprise for the production of metals by the method of direct reduction of iron from raw ore.

Also scheduled in the 11th Five-Year Plan is construction and start-up at the Cherepovets Metallurgical Plant of a blast furnace with a net volume of more than 5000 cubic meters. Construction is scheduled for three new small-capacity plants containing electric steel and rolling shops in the Far East, in Belorussia and

Moldavia -- they will operate on the basis of local scrap resources and will furnish high-quality rolled products to the enterprises in their regions.

Capital investment in ferrous metallurgy will increase in the current five-year plan by a total of approximately 30 percent over the 10th Five-Year Plan. These enormous funds must be utilized highly efficiently, so that each and every ruble spent will generate maximum return. Closely linked with growth and development of ferrous metallurgy in the 11th Five-Year Plan is resolution of basic socioeconomic problems, directed toward achieving an upswing in machine building, power engineering, transportation, chemical industry, agriculture, and other branches and sectors. The main task of our branch is radical improvement of quality and expansion of variety of metal products, which will make it possible substantially to improve the efficiency of utilization of metal in the nation's economy.

Much has already been accomplished, but many questions have not yet been resolved. For example, the strength properties of metal are to be improved, increasing the manufacture of rolled stock of low-alloy steel and with hardening heat treatment, with an increase in the variety of rolled products by bringing into production approximately 500 new and economical sections and 300 grades of steel. Production of efficient types of metal product is to grow at a priority pace -- cold-rolled sheet, high-precision bent and merchant shapes, highly-pure metal, electroslag, and vacuum remelting, and iron powders. It is also necessary to increase output of metal products with various types of coatings, which will extend product service life.

The Principal Directions devote considerable attention to further development of the fuel-energy complex, and especially production of oil and gas, and the transmission of oil and gas to the industrial centers of the Urals, the European part of the country and to the CEMA member nations. Metallurgical workers have a great responsibility in accomplishing this task, which is of great importance to the nation's economy. This branch must provide pipe to the petroleum and gas industry, and to the thermal and nuclear power industry. A manufacturing process is to be brought on-stream for producing large-diameter multi-layer pipe for high-capacity Arctic-configuration natural gas pipelines.

With the aim of improving production efficiency and quality of metal products, the Ministry of Ferrous Metallurgy, jointly with the State Committee for Science and Technology, has drawn up for the 11th Five-Year Plan specific combined scientific-technical programs specifying the development of new and advanced industrial processes: production of metal powders and new materials, coatings and products based on these powders; 1,420 mm diameter pipe for natural gas pipelines, designed for a working pressure of up to 120 atmospheres; pipe and other equipment for drilling oil and gas wells; metals with protective coatings; concentration of commercial minerals and adoption of a cyclic-continuous-flow process for surface-mining these minerals.

In addition, programs have been drawn up for solving major scientific and technical problems pertaining to all metallurgical processes: coke production, pig iron and steel production, out-of-furnace steel processing and casting, special techniques of obtaining high-grade steels and new, economical rolled sections and electrical steels.

An economy should be economical. This apt phrase, stated by Leonid Il'ich Brezhnev, has become a motto in the activities of this country's metallurgical workers. A persistent campaign to achieve economy and savings is in progress in all areas. Metallurgical workers are formulating and already accomplishing the task of bringing into production iron and manganese-containing waste, reducing the materials requirements of metallurgical production, including by reducing specific consumption of coke in the production of pig iron in connection with the extensive employment of natural gas, boosting the blast temperature, and improving the sintered ore. Measures are being taken to reduce steel consumption in the production of rolled stock by increasing the use of continuous casting units.

There is great potential for improving the efficiency of management in collection, storage and processing of scrap metal. Suffice it to say that more than 40 percent of all the steel in this country is produced from this raw material, which is cheaper than pig iron. Maximum utilization of scrap metal is a task of national importance. This is attested by the recently issued special decree of the CPSU Central Committee and USSR Council of Ministers, which specifies measures to improve the collection and processing of scrap metal in all branches and sectors of the economy. It is the task of metallurgical workers fully to utilize scrap for steel production.

Labor productivity is to be increased by 12-14 percent in the five-year plan. This is a complex but quite realistic task. In this area we follow the experience of the leading enterprises. In the last 10 years, for example, pig iron production has increased by 2 million tons at operating facilities of the Magnitogorsk combine, steel production has increased by 3.7 million tons, and finished rolled products output has increased by 1.9 million tons. The total number of industrial-production personnel has declined by 3000. Thus with a production increase of 36 percent, labor productivity has risen 47 percent.

This success became possible due to renovation and reequipping of the combine, mechanization and automation of production, improvement in organization of labor and management, repair and overhaul services, personnel training and worker mastery of an additional trade.

Engaging in nationawide socialist competition, the army of metallurgical workers, which numbers in the many thousands, is campaigning for successful accomplishment of the state plan for 1981 and the 11th Five-Year Plan as a whole. Competition leaders include the work forces at the Magnitogorsk and Nizhniy Tagil metallurgical combines, the Sokolovsko-Sarbayskiy and Ingulets Mining and Concentration combines; the Kerch', Taganrog and Hammer and Sickle metallurgical plants, the Chelyabinsk Tube Rolling Plant, the Khartsyzsk Pipe Plant, and the Volgograd Steel Wire and Cable Plant; the Magnezit Combine, the Kuznetsk Ferroalloys Plant and the Donetsk Coking By-Product Plant; the Volgograd and Chelyabinsk Vtorchermet production associations.

Socialist competition is a living productivity of the masses, grounded on a high degree of conscientiousness and initiative. There have been many valuable initiatives in this branch. The following initiatives have enjoyed broad support and dissemination: an initiative by the work force at the Magnitogorsk Metallurgical Combine, which called for competition under the slogan "High productivity and quality of labor -- a work standard for every day!"; an initiative on the part of leading excavator brigades -- to achieve the highest productivity of mine transfer equipment.

The authors of these patriotic initiatives display an example of how one should keep one's word. The members of the brigade of excavator operator Hero of Socialist Labor V. Mironenko, for example, at the Southern Mining and Concentration Combine, pledged to load 2,125,000 cubic meters of ore and rock from the mining face onto railcars in 1981. In actual fact more than 600,000 cubic meters were moved just in the first quarter. The brigade of excavator operator Hero of Socialist Labor Ye. Verevochkin at the Sokolovsko-Sarbayskiy Mining and Concentration Combine is equally far ahead of its year's socialist pledges.

A valuable initiative was authored by a steelmaker at the Azovstal' Plant, twice Hero of Socialist Labor G. Gorban', member of the CPSU Central Committee. He called upon the nation's steelmakers to compete under the slogan "From top-grade steel to rolled stock on specs, bearing the state Seal of Quality." A great many steelmakers heard and heeded his appeal. The initiator's brigade has already met its year's pledges pertaining to above-target steel production. All metal produced has strictly met order specifications. The brigade overfulfilled the first quarter's labor productivity target by 3.1 percent, with savings of 5.4 tons of pig iron, 15.4 tons of standard fuel, and 800 kilowatt hours of electricity due to skilled steelmaking.

An initiative by the excavator brigade of Hero of Socialist Labor P. Gil' has spread extensively throughout the branch. This brigade resolved to work in the 11th Five-Year Plan under the slogan "Complete the month's plan in 26 calendar days and meet the five-year plan target by the 115th anniversary of V. I. Lenin's birth!"

Socialist competition is gaining momentum in this branch of industry, for excellent end results according to the "Working Relay" principle, on the basis of the experience of the Cherepovets and Donetsk metallurgical plants, enterprises and organizations of associated branches and sectors of the economy -- suppliers of raw materials, other materials, metallurgical equipment, and metal customers. The experience of the Magnitogorsk Combine and the Asha Metallurgical Plant pertaining to adoption of brigade forms of labor organization and incentive has also evoked lively response, as have the Taganrog and Elektrostal' plants, which have engaged in competition on the basis of personal and brigade economy records.

All these metallurgical worker initiatives and ideas are in the final analysis aimed at successful fulfillment and overfulfillment of the targets of the first year of the 11th Five-Year Plan and the tasks assigned to this branch by the resolutions of the 26th CPSU Congress.

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ACTIVITIES OF TULACHERMET SCIENTIFIC-PRODUCTION ASSOCIATION

Moscow ZNANIYE -- SILA in Russian No 2, Feb 81 pp 7-9

[Article by A. Manokhin, corresponding member of the USSR Academy of Sciences, general director of the Tulachermet Scientific-Production Association (interview worked into article form by A. Valentinov): "A New Metallurgy Is Born"]

> [Text] Utilization of completed project results is presently being given primary emphasis in the complex chain linking science with production. How can one incorporate, with maximum speed and effectiveness, scientific research results in factory shops? Following a long search, a variant which is optimal for the nation's economy has been found -- establishment of branch scientific-production associations.
>
> The activities of the Tulachermet Scientific-Production Association are an example of such an alliance between science and practical production. Organized seven year ago, in such a short period of time it has become a most essential and effective component in the system of management and control of technological advance in this industry. All state-of-the-art trends in the world metallurgical industry are reflected in its activities.

A scientific research and design institute, as well as an experimental-production complex are operating in our organization, just as in scientific-production associations established in other branches of industry. But there is also a special complex for incorporation into production of completed project results. The existence of this complex and the scale and volume of work assigned to it give to the activities of the Tulachermet Scientific-Production Association that character which places it in a very special position among other similar organizations. Suffice it to say that some of the products we produce are not made anywhere else -- not only in this country but anywhere else in the world.

But of course the significance of our association for this industrial branch is determined not only by the manufacture of unique products. Unique project results are for the future. Born today and gradually incorporated by plants, they serve as a foundation, as it were, for that qualitative leap forward which will be made by the ferrous metallurgical industry -- I am talking about total replacement of traditional industrial processes. But until such a leap forward is accomplished, the main task is to reveal deep reserve potential of traditional processes and to revise them from the standpoint of maximum economic return.

I can cite a concrete example of research aimed in this direction. And not just research, but practical results as well. Take, for example, the blast-furnace process. The ideal solution is to eliminate it altogether, to move to direct reduction of iron from ore. This idea is already being implemented on a commercial scale at the Staryy Oskol Combine, which is under construction.

Cokeless metallurgy will continue vigorous development, but its "golden age" lies in the future. For the time being blast-furnace production remains one of the principal elements of the industrial complex. The so-called "tandem process" -- repeated use of blast-furnace gas -- is more preferable here. This process is especially effective when pelletized ore is used as furnace charge. A process developed by us and tested at the Beloretsk Metallurgical Combine indicated that a 30 percent coke savings is obtained together with an increase in furnace output. And up to 100 kilograms of short-supply raw materials can be saved on each ton of pig iron produced. We have found similar reserve potential in steelmaking production in heating ingots prior to rolling.

Of course it is very important for today's metallurgical industry to find deep reserve potential in traditional processes. But they will not determine tomorrow's technology. Of all scientific research project results, we can cite three which in my opinion are the most promising. The first of these is continuous casting machines (MNLZ).

Continuous casting machines are not a new invention (they were formerly called "ustanovki nepreryvnoy razlivki stali"). Two types had been in use up to the present time -- vertical and radial -- bulky structures containing large amounts of metal, requiring considerable space in the shops.

Continuous steel casting possesses unquestioned advantages: usable metal yield amounts to 98 percent on these units, while it does not exceed 70 percent with casting in ingot molds and subsequent rolling. At the present time, however, only 10-15 percent of produced metal is MNLZ cast. One of the reasons for this is the excessively small variety of castings presently produced.

Tulachermet began with significantly expanding the capabilities of vertical and radial units. They are presently obtaining three-layered steels for plows on these machines -- soft metal in the center, and hard metal on the sides. Another example is ingots for manufacturing railcar wheels. Steel consumption is reduced by 135-150 kilograms per ton of metal when casting wheels on MNLZ, while in monetary terms savings amount to 4-5 rubles per ton. This represents considerable success. We now have all the conditions necessary for much more extensive adoption of this advanced process, which will give the economy an additional 10 million tons of metal without bringing new steelmaking facilities on-stream. But we proceeded beyond this point and developed a quite unique MNLZ -- a horizontal type.

The idea per se is not new. Attempts were made to implement it in the last century. Later an American by the name of Laying even took out a patent on a similar machine, but the idea remained on paper. The readers might picture a highly complex, fantastic mechanism, stuffed with electronics. After all, it is practically officially called the "machine of the century" in the metallurgical industry. But in actual fact it is such a simple design that both its layout and principle of operation are immediately graspable.

A light, welded frame, for which a corner can be found in any shop, and on the frame everything required by an MNLZ -- a receiving hopper for the molten metal, two ingot molds for continuous casting, two drawing mechanisms, and roller tables. A primitive setup, it would seem, but it turns out product which amazes even the experts. For example, solid and hollow castings for seamless pipe of conventional and difficult-to-deform steels. This machine evoked enormous interest at an international exhibit in Stockholm.

Capital outlays to build a horizontal MNLZ are insignificant, and yet it produces good-quality metal. It is for this reason that plants are so enthusiastic about it, and not only metallurgical plants, but automotive and machine building plants as well, including ZIL. The latter plant is building for itself -- on the basis of Tulachermet plans -- an industrial-type horizontal MNLZ. After it is completed, the Tula metallurgical workers will make on this machine parts for ZIL of metal possessing special properties. Nor have foreign entrepreneurs remained indifferent toward it -- the Italian Danieli firm purchased two years ago a license to build one.

A second promising new innovation is an oxygen converter with bottom blast. A situation which has developed in steelmaking required development of this converter. A large quantity of steel is still produced in open-hearth furnaces, the "voraciousness" of which drives economists to despair. They are fired primarily by residual oil. Even when natural gas and oxygen are utilized, a ton of open-hearth steel requires 40 kilograms of crude oil, and as much as 100 kilograms without them. But existing open-hearth shops should not be torn down and replaced with converter shops -- the extended timetable and cost of new construction place in doubt for the time being the economic and production advisability of such an action. Simple replacement of an open-hearth furnace with a conventional converter with top blast also fails to solve the problem: such a unit does not fit well within the dimensions of shops, requiring substantial renovation. But the "golden flare" in the open-hearth furnace continued to concern the experts. And finally a solution was found. The first Soviet converter unit with bottom oxygen-fuel blast was developed at Tulachermet, a unit which is easily accommodated in any open-hearth shop. Testing of a 130-ton converter at the Zhdanov Metallurgical Plant imeni Il'ich produced excellent results. Suffice it to say that a ton of steel costs 2 rubles less. But the main thing is that the new converter offers a broad range of grades of steel it can produce. The unit is especially good for producing special grades, such as transformer steel.

And finally, the third development which I consider to be one of the association's most important achievements is the production of ferrovanadium. This is a unique "elixir" for metal, which gives it particular strength. Essentially this project should have been placed first, for the new Tulachermet Scientific-Industrial Association "began" namely with this project. At that time a team of scientists proposed producing ferrovanadium in a closed cycle -- without any production waste. This was a noble task or, more precisely, a supertask, since it would resolve the problem of environmental protection simultaneously with a production problem. It was a supertask accomplishment of which would determine whether or not the new association was to exist. An organization embodying an alliance between science and industry was created precisely in the course of solving this great problem. The time required to complete a research and development project was sharply reduced and, most important, incorporation of project results into production was accelerated by 5-10 years. The country was presented with a new process of producing ferrovanadium which is harmless to the environment. This project was awarded a Lenin Prize.

Metal powders constitute the immediate future of metallurgy, and most probably not only the near future. At the very least powders can solve many problems which currently concern metallurgists. And Tulachermet has opened up wide the door for powders to enter Soviet undustry.

Today, for example, we need large quantities of so-called magnetostable materials. Usually they are obtained by utilizing costly cobalt, nickel, and samarite, in a highly complex, multistage process. As a result the cost of these materials is very high. They can be made from powders at several times less cost.

Manufacture of composite high-speed tools by powder metallurgy methods increases their durability double to triple and makes it possible additionally to save on every thousand tons of material 50 tons of extremely short-supply molybdenum, tungsten, cobalt, vanadium, and chromium.

Tulachermet has developed an entire line (approximately 150) of materials for application of wear-resistant coatings. They "get along" fine with plasma and laser units. Jaw-crusher cones, electric traveling crane wheels, plowshares, tractor road wheels, mining tools, machine parts and assemblies subjected to most intensive wear have much longer service lives with such coatings.

The list goes on and on.

The "Tula variant" has fully proven itself. Every day new industrial processes are born in the association's laboratories, testing areas, and shops. A new metallurgy is being born.

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FERROUS METALLURGY IN KAZAKHSTAN

Alma-Ata KAZAKHSTANSKAYA PRAVDA in Russian 13 Aug 81 p 2

[Article by R. Islamov, chief of the nonferrous and ferrous metallurgy department, Kazakh SSR Gosplan: "Ferrous Metallurgy of Kazakhstan"]

[Text] The 26th CPSU Congress defined as the main task of the new five-year plan securement of further growth in the prosperity of Soviet citizens on the basis of steady forward development of the economy and more efficient utilization of this country's production potential. A primary role in accomplishing this task is to be played by heavy industry and, in particular, one of its principal branches -- ferrous metallurgy.

This branch of industry is also acquiring increasing significance in the economy of Kazakhstan. It includes such large enterprises as the Sokolovsko-Sarbay, Lisakovsk, and Donskoy mining and concentration combines, the Karaganda Metallurgical Combine, the Yermak Ferroalloys Plant, plus others. Approximately 960 million rubles were spent during the last five-year plan just on construction of production facilities. This capital investment resulted in completion of construction on a second coal dressing mill at the Karaganda Metallurgical Combine, a smelting shop at the Yermak Ferroalloys Plant, and new ore production facilities at the Donskoy Mining and Concentration Combine, the Kazakh Alumosilicate Refractories Plant, and a number of other facilities.

Ferrous metallurgical industry output volume increased by 15 percent during the five-year plan, totaling 1.2 billion rubles per year. There was a particularly appreciable increase in production of pig iron, coke, and steel. The republic overfulfilled the targets of the 10th Five-Year Plan in production of a number of important items -- iron and chromium ores, pelletized and sintered iron ore. Its role is also growing in the national metallurgical output balance. The Sokolovsko-Sarbay Combine, for example, has become one of the main raw materials suppliers for metallurgical plants in the Urals. The Donskoy Mining and Concentration Combine produces 96 percent of the nation's chromium ore, and a significant percentage of its output is exported abroad. The Yermak Ferroalloys Plant is one of the country's largest enterprises producing silicon-base ferroalloys. The Karaganda Metallurgical Combine will become in the near future one of the principal producers of high-quality rolled stock -- a diversified variety of thin steel sheet.

Considerable work is also being done at enterprises to raise the technological level of production and to adopt new equipment and advanced technology. Kazakhstan's Magnitka, for example, is rolling side-member stock for the Kama Truck Plant, a process of double-layer sintering of Lisakovsk ore has been developed and adopted, as has an improved process of blowing iron phosphides in oxygen converters. At the Sokolovsko-Sarbay Mining and Concentration Combine, 81 percent of total production bears the state Seal of Quality.

At the same time serious deficiencies are also occurring in the operations of ferrous metallurgical enterprises. Correction of these deficiencies constitutes a large reserve potential for further increasing production and improving production efficiency. There still occurs considerable downtime of blast furnaces, converters and plate and sheet mills at the metallurgical combine. High-output electric melting units installed during the last five-year plan at the Yermak Ferroalloys Plant are being underused by one third, as a consequence of which this enterprise regularly fails to meets its state plan targets. The main reasons for this situation include delay in construction of enterprise repair-auxiliary service, and lack of advance-planned training of skilled worker cadres for the principal production facilities.

The necessity of the earliest possible correction of deficiencies and all-out increase in metal product output volume is predetermined by the targets for the new five-year plan specified at the 26th CPSU Congress. By the end of 1985 this republic is targeted to boost pig iron production by 5.2 million tons (with an 8.8 percent increase over 1980), and an increase in output of finished rolled stock to 5.23 million tons (a 27 percent increase). Commodity output volume will increase by one fourth as a whole, and will total 1.51 billion rubles.

Such a growth is to be achieved both by further improvement and intensification of production and by expansion and renovation of existing enterprises. At the Sokolovsko-Sarbay Mining and Concentration Combine, the Kurzhunkul' Mine will come on-stream, with an annual production capacity of 2 million tons of iron ore. At the Lisakovsk Combine iron ore concentrate output capacity will expand by 2.4 million tons. Underground chromium mines will come on-stream at the Donskoy Combine. The first unit of the Kacharskiy Mining and Concentration Combine, with an annual output capacity of 5 million tons of iron ore, is scheduled to come on-stream by the end of the five-year plan.

A particularly large amount of work is to be accomplished at the Kazakh Refractories Plant. This year plans call for bringing on-stream capacities to produce 29,800 tons of alumosilicate products. By the end of the five-year plan this enterprise will put into production a high-output corundum and mullite-corundum refractories shop as well as the second unit of an experimental shop.

The work force at the Yermak Ferroalloys Plant must carry out a large aggregate of measures aimed at correcting design deficiencies in process equipment, renovation and expansion of auxiliary facilities. Parallel with this, plans also call for further expansion of enterprise facilities by bringing on-stream three additional electroferroalloy furnaces with an annual output capacity of 90,000 tons of ferrosilicon each.

Plans call for substantial expansion of the network of initial processing and processing enterprises of the Kazvtorchermet Association. It will be enlarged by 14 shops for processing scrap metal. A total of approximately 1.4 billion rubles in capital investment will be spent at ferrous metallurgical enterprises by the end of 1985.

One of the main tasks in the area of development of this public's ferrous metallurgical industry is securement of stable and uniform-running operations at the metallurgical combine. For this it is necessary to complete at an earlier date construction of a thin steel sheet shop, the first unit of which, with an output capacity of 450,000 tons, should come on-line by the end of this year, as well as renovation of Blast Furnace No 1, boosting its annual output capacity by 200,000 tons of pig iron, plus construction of an eighth battery of coke ovens. The Karaganda metallurgical workers will also be bringing on-line equipment for metallurgical processing of Lisakovsk roasting-magnetic concentrators with comprehensive utilization of raw material.

Especially large tasks must be accomplished at the combine in connection with the forthcoming modernization of its present rolling-mill equipment and movement on-stream of thin steel sheet shop facilities. In order to achieve the targeted finished rolled product output volume and to supply the new shop with starting strip of the required quality, it is necessary to renovate the 1700 mill and increase its output capacity by 960,000 tons of product per year. Preparations for this are proceeding slowly at present, however. The design documentation has not yet been completed, and orders have not been placed for manufacture of required equipment, and yet the scheduled renovation time is not far off -- 1983-1984.

On the whole, however, in spite of a number of shortcomings, this republic's ferrous metallurgical enterprises have successfully commenced the new five-year plan. The seven-month product sales target has been met, and the target pertaining to production of major products has been more than met. The national economy has received an additional large quantity of chromium ore, pig iron, steel, and coke. Such a good labor start by metallurgical workers, if production reserve potential which is everywhere available is utilized even more fully, will become a reliable foundation for successful accomplishment of the targets of the entire five-year plan.

3024
CSO: 1842/171

HEAT TREATMENT

UDC 621.785.375:620.186.5:669.245

RECOVERY AND RECRYSTALLIZATION IN KhN55VMTKYu NICKEL ALLOY

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, Aug 81 pp 48-51

PIGROVA, G. D. and BRAUER, T. N., Scientific-Industrial Department, Central Boiler and Turbine Institute imeni I. I. Polzunov

[Abstract] Recovery and recrystallization in the KhN55VMTKYuVD (E1929VD) nickel alloy after heat treatment were studied, to determine the effects of cold working and structural factors on the kinetics of these processes as well as the dependence of the kinetics on the temperature-time parameters of the annealing treatment. Ingots of this alloy (0.079% C, 5.9% W, 10% Cr, 0.35% V, 4.9% Mo, 1.6% Ti, 4.1% Al, 15.2% Co) with a 30-40% high content of the dispersed γ'-phase were, after heat treatment (1000°C 2 hrs + 1190°C 2 hrs + 1050°C 1 hr + 1000°C 1 hr + 900°C 16 hrs), deformed at room temperature to 4, 11 and 22% sets. Recovery was measured initially through internal friction and then by x-radiography. The relation between recrystallization, primary followed by collective, and the state of the dispersed phases was established by chemical and x-ray structural analysis of specimens soaked at 950-1200°C for 1 hr and 10 hrs. The results indicate that recovery in the cold worked alloy depends on the annealing conditions: initial vanishing of excess point defects occurring at 300°C, no structural changes occurring at 500°C, subsequent polygonization with attendant annihilation of line defects occurring at 700-900°C, and sufficient perfection of the intergranular structure occurring at 1180°C. The temperature of primary recrystallization (1100-1120°C) is determined by the dissolution of the hardening γ'-phase, while collective recrystallization develops noticeably at and above 1150°C, after dissolution of the carbide phases. Figures 3; references 10: 9 Russian, 1 Western.
[172-2415]

UDC 620.178.2:669.14.018.8

EMBRITTLEMENT OF FERRITIC-AUSTENITIC STEELS DURING AGING AT ELEVATED TEMPERATURES

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, Aug 81 pp 43-46

BANNYKH, O. A., GULYAYEV, V. N., ZAKHAROVA, M. I., NIKONOROVA, I. A. and KUZNETSOV, V. S., Institute of Metallurgy imeni A. A. Baykov, Scientific-Industrial Association "Energiya"

[Abstract] Specimens of the ferritic-austenitic steels 08Kh22N67 and 08Kh18G8N2T were tested mechanically, after having been soaked for 30 min at and then quenched either from 950°C with subsequent aging at 350°C for 1000 hrs or from 1100°C with subsequent aging at 300 and 400°C for approximately 4500 hrs. The tensile strength and the 0.2% yield strength as well as the microhardness were measured after aging at those various temperatures. The results reveal a definite relation between toughness and microhardness, the former decreasing to below 0.1 MJ/m^2 as the latter increases above H 170. The results of x-ray spectral and fractographic analysis indicate the same mode of ductile fracture in both steels and that aging causes some embrittlement at temperatures below 400°C. This "475°C" brittleness threshold was found to drop with increasing length of the aging period, the embrittlement being not due to changes in the microstructure or due to redistribution of the alloying elements but due to changes in the ferrite substructure.
N. F. Shemyatovskaya and B. S. Lyubimtsev participated in the study. Figures 4; references 6: all Russian.
[172-2415]

UDC 539.3:620.18:620.17:669.245

EFFECT OF DEFORMATION ON STRUCTURE AND PROPERTIES OF CAST NICKEL ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, Aug 81 pp 38-41

MASLENKOV, S. B. and BUROVA, N. N., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] A study was made of the heat-resistant dispersion-hardened cast nickel alloys KhN62MKYuTB (with tantalum) and KhN64KYuVMT (with titanium) to determine the effect of deformation at high temperatures of 1000-1100°C on their properties. Specimens of these alloys produced by the method of oriented crystallization, to improve their plasticity, were deformed by extrusion into shells. Mechanical tests and microstructural analysis revealed that high-temperature deformation causes a complete breakup of the hardening carbide skeleton, without dissolution of the carbides and with retention of the excess eutectic γ'-phase, as well as an anomalous increase of the plasticity and a sharp decrease of the

heat resistance at those temperatures. Fast loading of thus deformed specimens transforms vacancies to cracks, which results in brittle fracture. Figures 4; references 5: 3 Russian, 2 Western.
[172-2415]

UDC 669.295

THERMAL CONDITIONS DURING VACUUM SEPARATION OF A MAGNESIUM MASS REACTING UNDER HEAT

Moscow TSVETNYYE METALLY in Russian No 7, Jul 81 pp 60-62

MAL'SHIN, V. M., CHEREPANOVA, Ye. A., ANDREYEV, A. Ye., YATSENKO, A. P. and PERESADA, Z. V.

[Abstract] During separation of the reactant mass by the vacuum process in production of titanium sponge a condensate forms which consists of magnesium and magnesium chloride. The process was simulated on a digital computer for an analysis of the thermal conditions, temperature transients and heat transfer coefficients under varying heat loads in the furnace, in the reactant mass, in the screen, and in the condenser over a process time of 38 hrs and beyond. On the basis of the results, a scheme is proposed for cooling the condenser so as to ensure a dense titanium condensate and avoid its contamination by oxygen through condensation and combustion of magnesium and magnesium chloride. The scheme involves, essentially, water cooling of the condenser surface till after the temperature has peaked and subsequent air cooling for the remainder of the process. Figures 2; references 2: both Russian.
[158-2415]

UDC 539.43:669.721.5:620.19

FATIGUE CRACK DEVELOPMENT IN MAGNESIUM ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 17, No 3, May-Jun 81 (manuscript received 29 Jul 80) pp 11-18

YAREMA, S. Ya., ZINYUK, O. D., OSTASH, O. P., KUDRYASHOV, V. G. and YELKIN, F. M., Physico-Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, L'vov

[Abstract] Four magnesium alloys were tested for fatigue resistance: MA2-1 and MA8 (magnesium-based α-phase with a c.p.h. lattice and intermetallic precipitates), MA18 (β-phase solid solution of magnesium in lithium with a b.c.c. lattice), MA21 (magnesium-based α-phase with a c.p.h. lattice and lithium-based β-phase with a b.c.c. lattice). Disk specimens cut from annealed strip with cracks induced across the direction of rolling were tested in the hard loading mode with almost symmetric tension cycles at a frequency of 17-20 Hz in laboratory air with 40-60% humidity. The rate of crack growth was measured and fatigue fracture diagrams were plotted, indicating similar trends for all four alloys. These diagrams can be approximated, especially closely in the intermediate range, with a power-law dependence of the cracking rate on the stress intensity coefficient. A fractographic examination has revealed, furthermore, that at low cracking rates the cracks remain straight and at cracking rates above 10^{-6} m/cycle the plane of fracture rotates into a position at a 45° angle to the cross section of the specimen. While there are slight differences between the fracture reliefs of MA8, MA21 and MA2-1 alloys, that of MA18 alloy differs noticeably. Figures 4; references 17: 15 Russian, 2 Western.
[157-2415]

NONFERROUS METALLURGY

NONFERROUS METALLURGY WASTE-FREE PRODUCTION

Moscow TRUD in Russian 8 Jul 81 p 2

[Article by V. Durasov, USSR deputy minister of nonferrous metallurgy: "Production Without Waste"]

[Text] Today nonferrous metallurgy serves as a source of materials for the most modern, rapidly developing branches of industry: instrument engineering, nuclear power engineering, aviation, and space exploration. And although we are producing increasingly larger quantities of nonferrous metals each year, the requirements of the nation's economy are still not being fully met.

Therefore the problem of utilization of secondary resources in nonferrous metallurgy has recently become particularly critical. In the "Principal Directions of Economic and Social Development of the USSR in 1981-1985 and the Period up to 1990," we read in the section covering targets pertaining to nonferrous metallurgy: "Substantially increase the collection and processing of nonferrous metal scrap and waste."

A few days ago the CPSU Central Committee and USSR Council of Ministers issued a decree entitled "On Stepping up Work to Achieve Economy and Efficient Utilization of Raw Materials, Fuel-Energy and Other Material Resources." This document specifies concrete measures to achieve a sharp reduction in waste, and fuller utilization of secondary resources in production.

Procurement of scrap and waste materials has almost doubled in the last 10 years. The cost of annual production of remelted alloys from scrap and waste materials is 180 million rubles less than the cost of producing the same quantity of metals from crude ore. Consumption of standard fuel to produce one ton of remelted aluminum alloys is 30 times less, and copper five times less than in producing these alloys from ore. In short, it is economical and profitable to obtain nonferrous metals from waste materials.

The question is how to improve the collection of scrap and waste metal so that not a single kilogram is lost. There are several ways. The most important of these are improvement in the quality of procured secondary resources, and drawing into production nonferrous metal waste which is not being utilized at the present time.

Is the term "quality" applicable to such seemingly minor-importance production waste as shavings, chips, sludges, etc? Report data and enterprise surveys indicate that from 60 to 80 percent of nonferrous waste is delivered mixed (low-grade). If one considers the fact that there are more than 130,000 such enterprises and that they are scattered all over the country, one can easily imagine what a complicated matter it is to separate low-grade waste by metals and grades of alloys. In addition, at the present time there is no efficient method of separating bronze chips from brass, or copper from aluminum, not to mention grades, and yet approximately 600,000 tons just of chips are formed each year, a large percentage of which is mixed, devalued both in the process of machining nonferrous metals and during careless collection, storage and transfer. Why does this happen?

As indicated by checks performed by the State Secondary Nonferrous Metals Inspectorate, there are several factors involved. In the first place, at many enterprises there is no organized system of collecting waste nonferrous metals which would guarantee that they do not get mixed. Secondly, there is no material incentive for workers to ensure at all stages of production completeness and quality of collected scrap and waste metal. Third, the enterprise manager is today responsible for meeting the overall target for delivery of waste nonferrous metals, but not broken down by types (bronze, brass, copper, lead), and particularly by grades of those alloys which the enterprise consumes.

Machine tools which machine different nonferrous metals and alloys, as well as ferrous metals, are frequently not isolated from one another. Collection of machining chips is assigned as a rule not to the machine tool operators but to cleanup personnel, who mix them. The same thing takes place later when metal waste is collected and transferred to a central storage point and loaded into a freight car or container. And since finished product scrap is not counted, the technical inspection division does not check to see the quality or grade of scrap being shipped to customers. The result is deplorable. High-grade nonferrous metals are received by an enterprise in the form of sh[illegible], sections, castings and forgings, while production waste contains a mixture of nonferrous and ferrous metals.

Last year alone tens of thousands of tons of copper-base mixed waste were processed at the Kirovgrad Copper Smelting Combine imeni S. M. Kirov, waste which cannot be separated by types of metals. Only copper is extracted at this enterprise, while 15,000 tons of zinc, approximately 2,000 tons of tin and lead, and all the aluminum, nickel, cobalt, and hard alloys (tungsten and molybdenum) are irretrievably lost.

One can also cite many deficiencies in the utilization of production-line rejects in the manufacture of radio electronic equipment, electric lamps and bulbs. Everybody knows that today's radio electronic equipment part contains almost the entire spectrum of nonferrous metals. The majority of enterprises, however, do not perform separation on parts rejects but ship them "in bulk" to the enterprises of Soyuzvtortsvetmet, which leads to devaluation of many nonferrous metals contained in these parts.

Processing of old television sets brought by the public to receiving stations serves as a vivid example. Last year, for example, only 1,000 tons of copper were obtained from 14,000 tons of initial raw material, while 13,000 tons of nonferrous metals (aluminum, nickel, cobalt, tungsten, molybdenum) and high-grade steel were lost with the meltdown slag. I believe that there is a need to set up special sections for disassembly of electronic equipment and separation by types of nonferrous metals at manufacturing enterprises.

But we could also cite other examples, where each year enterprises turn in scrap and waste metal on a regular basis and exclusively of high quality. These include the Kamkabel' amd Uralmash plants, Riga VEF, the Tbilisi Aircraft Plant imeni Dimitrov, and others. Shops have been set up at these enterprises for the collection and processing of scrap and metal waste, containing special scrap processing equipment (presses, magnetic separators, crushers, centrifuges, etc). Collection of metal waste is handled either by the workers themselves or by qualified individuals who are acquainted with the properties of nonferrous metals and alloys. There is a material incentive system in operation, both for plan fulfillment and for quality of collected waste metal. At a certain plant in Tul'skaya Oblast, for example, machine tool operators receive four and a half kopecks for every kilogram of collected clean chips, but only one and a half kopecks for mixed chips. As a result, the monthly addition to earnings is either 36 rubles or only 12 rubles. The material incentive fund outlay amounts to 45 rubles per ton of chips, while the price gain due to improved quality amounts to 210-300 rubles. In addition, however, there is also the effect of order and proper procedure in production, and a thrifty worker attitude toward metal from the standpoint of the nation. Also of interest is the experience of the Rybinsk Cable Plant, where every worker, after her shift is over, turns in waste nonferrous metals to a special receiving person in a sack, by weight, with a journal entry made. No bonuses are paid here, but an excellent system of conservation of public resources is in operation, which has become a fine tradition.

Nor can we ignore the economics of collecting high-grade waste. The management at Perm' Kamkabel' has calculated, for example, that it is unprofitable to turn in low-grade production waste metal, and therefore they have set up a scrap separation section. In the very first year a profit of approximately 1 million rubles has been earned by increasing purchase prices on scrap and waste nonferrous metals turned in. A shop is presently under construction at the plant for processing cable production process waste.

It is possible to increase procurement of scrap and waste metal while avoiding mixing and devaluation of the secondary nonferrous metals resources being formed. Resolution of this problem alone will provide the nation with an additional more than 120,000 tons of short-supply nonferrous metals. As you can see, this constitutes a substantial reserve potential.

In my opinion economic measures must be prescribed for improving the quality of scrap and waste metal. It is necessary to include revenues from sale of scrap and waste metal in the plan and commodity (net) production performance report. Then an enterprise which turns in 1,000 tons of scrap brass per year, for example, can generate revenues of either 500,000 rubles, if the scrap is high-grade, or 180-200 thousand if it is mixed. Where is one to obtain the 300,000 plan shortfall? Any business executive will quickly find and eliminate the causes of mixing waste metal.

Another important reserve potential for increasing the procurement of secondary resources is the drawing of scrap and waste metal into processing which is not presently being utilized. Their quantity totals, according to incomplete figures, 320,000 tons. Also included in this category is 80,000 tons of aluminum not collected with household discard scrap, 15,000 tons of zinc in batteries, and several thousand tons of tin lost with discarded cans.

Unfortunately, much metal fails to be collected due to process deficiencies and a lack of responsibility on the part of supervisory personnel of enterprises, shops, and sections. There are many examples. These include the Murom Radio Plant, the L'vov Iskra Production Association, the Tomilino Semiconductor Instrument Plant, the First Moscow Radio Parts Plant, many automotive servicing and maintenance stations, and Sel'khoztekhnika associations. Cases of waste tungsten and molybdenum being swept down the drain and chips and defective parts hauled to the dump together with trash have been recorded at these organizations.

Here is a concrete example. Every year 17,000 tons of lead are lost together with battery scrap. In many union republics decisions have been made which stipulate that new storage batteries shall be given only in exchange for old ones. The collection of old storage batteries, including from the individual owners of automobiles, will become law effective January 1982. Effective 1981, the price paid for a worn-out storage battery has been raised from 2 rubles 60 kopecks to 5 rubles.

However, as indicated by an inspection of Sel'khoztekhnika and Avtotekhobsluzhivaniye enterprises in March of this year, many organizations issue or sell new storage batteries without exchange for old batteries, and in many instances processing of storage battery scrap is performed incorrectly (the cases are flattened by bulldozers), whereby a large part of the lead-containing sludge is lost.

In short, we possess considerable reserve potential for increasing the collection of scrap and nonferrous waste metal. In order to implement this potential, it is necessary first and foremost to institute rigid monitoring of utilization of secondary metals at enterprises, organizations and agencies. Resolution of this problem will make it possible to improve, without any particular expenditures, supply of aluminum, lead, copper, zinc and other metals to the economy.

3024
CSO: 1842/153

UDC 621.762

COMPACTION OF TUNGSTEN AND TITANIUM CARBIDES AND THEIR MIXTURES WITH NICKEL DURING HEATING UNDER HIGH PRESSURE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 81
(manuscript received after revision 1 Nov 80) pp 28-32

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[Abstract] Powders of tungsten carbide and titanium carbide were produced by the method of self-propagating high-temperature synthesis. These powders, also their mixtures, were then compacted with 6 wt.% Ni during heating up to 1800°C under high pressures up to 80 kbar. For a study of the compaction kinetics, the electrical resistivity was measured as a function of both temperature and pressure. Vickers hardness and microhardness were tested with a 10 kg load and a 200 g load, respectively; x-ray structural analysis was performed with a URS-2.0 instrument and a Dron-2.0 instrument using the radiation from a copper source. Each carbide was found to behave differently. The compacting of tungsten carbide under a pressure of 25-35 kbar can be improved only by raising the temperature. Compacting of titanium carbide at a constant temperature improves under a higher pressure, although the process becomes slower. An almost nonporous titanium carbide is produced under a pressure of 53 kbar, but specimens held under such a pressure for 8 min will crack after the pressure has been removed. Figures 5; references 13: 12 Russian, 1 Western.
[155-2415]

UDC 621.762

MECHANICAL PROPERTIES OF COMPOSITE MATERIALS BASED ON SILICON NITRIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 81
(manuscript received after revision 1 Nov 80) pp 73-77

GRIGOR'YEV, O. N., CHUGUNOVA, S. I., SHATOKHIN, A. M. and YAROSHENKO, V. P.,
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[Abstract] Hot-pressed silicon nitride with various refractive additives is used as the basis of ceramic materials for cutting tools. A study was made to determine the Vickers hardness and the toughness of such materials based on technical-grade β-modification of Si_3N_4 and containing dispersed particles of an additive (TiC, HfC, NbC, TaC, WC, TiN, TaN, $TaSi_2$) with a higher coefficient of thermal expansion. Both the hardness and the toughness were measured as functions of the temperature up to 800°C and both were found to decrease with rising temperature, whether the material contained no additive, carbides, nitrides, or silicides. Both the hardness and the toughness, as well as the tensile strength in bending (notched-bar test), were also measured as functions of the TiC content. The data indicate that maximum hardness and toughness are attained with 15 vol.% TiC, while the tensile strength drops sharply as the TiC content is increased beyond 10 vol.%. According to the theory of brittle fracture, 15 vol.% TiC should ensure maximum stability of the material under conditions of abrasive wear. Figures 3; references 11: 3 Russian, 8 Western.
[155-2415]

UDC 621.762

PROPERTIES OF HOT-PRESSED COMPOSITE MATERIALS IN THE $TiN-Al_2O_3$ CLASS PRODUCED FROM POWDERS OF FINE-DISPERSE ALUMINUM OXIDE AND PLASMOCHEMICAL TITANIUM NITRIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 81
(manuscript received 12 Jul 80) pp 61-64

VIL'K, Yu. N., MNATSAKANYAN, Ye. D., ORDAN'YAN, S. S., CHEKRYGINA, T. M.,
VDOVIN, V. N. and MILLER, T. N., Leningrad Technological Institute

[Abstract] Powders of fine-disperse aluminum oxide and plasmochemical titanium nitride can be mixed by hot pressing to form composite materials with excellent characteristics. In this study of such composite materials with the TiN content varying from 10 to 50 wt.% measurements were made of their hydrostatic density, Rockwell hardness, Poisson ratio, moduli of elasticity and shear, and the velocity of longitudinal elastic waves. Empirical relations were established for these properties as approximately linear functions of the TiN content. Although some departure from additivity of the properties occurs, this departure is significant only with respect to the moduli of elasticity and shear: rather

than decreasing linearly from 100% TiN to 100% Al_2O_3, both dip to a minimum for the approximately 30% TiN + 60% Al_2O_3 composite. Such a softening is attributed to a more intense interphase chemical reaction, which produces titanium oxide, at the grain boundaries. Figures 1; references 10: 9 Russian, 1 Western.
[155-2415]

UDC 621.762

MECHANISM OF ELECTRIC CURRENT CONDUCTION IN THICK FILMS OF COMPOSITE MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 81
(manuscript received after revision 3 Jan 81) pp 50-52

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[Abstract] Thick films of titanium boride and chromium boride were produced by conventional technology from powder, by deposition on dielectric substrates and subsequent heat treatment in air. Measurements have revealed that the electrical resistance of such thick films decreases (TiB_2) or increases (CrB_2) as the temperature rises from -196 to +200°C, the temperature coefficient of electrical resistance thus not changing its sign throughout this range in either case. According to an earlier proposed empirical inverse-power relation for the temperature dependence of the temperature coefficient of electrical resistance applicable to thick boride films, however, this coefficient should become zero at some temperature: in the liquid-helium range for CrB_2 and above 100,000°K for TiB_2. For a practical experimental verification of the electron percolation model of electric current condiction in this case, thick-film mixtures of both borides in various ratios were prepared so as to bring the temperature T_{min} corresponding to a zero temperature coefficient of electrical resistance within a measurable temperature range. Here the experimental data agreed fairly closely with theoretical calculations on the basis of that relation; also the T_{min} temperature was found to become higher with an increasing content of glass binder in the film.
[155-2415]

STEELS

UDC: 669.017+539 14/15

NEW METAL STRUCTURAL MATERIALS--RQM (REINFORCED QUASI-MONOLITHIC) AND QL (QUASI-LAMINAR)

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 81
(manuscript received 20 Jan 81) pp 17-24

PATON, B. Ye. and MEDOVAR, B. I., Kiev

[Abstract] Following the ideas of N. T. Gudtsov who suggested almost 30 years ago that large steel ingots be cast with "macrocoolers" or large rods or plates of solid metal inserted into the ingots as they were poured to prevent local overheating, the authors studied multi-ton sheet ingots of oxygen-converter steel (20-22 tons) designed for rolling to produce thick sheets (17.5-150 mm) on a modern 3600 sheet-rolling mill at the "Azovstal'" Plant. To prevent fusion of the reinforcing insert with the body of the ingot, coatings widely used in the production of bimetals are applied to the surface of the reinforcing insert. If welding into the ingot is required, the surface of the insert is cleaned and coatings are applied which encourage this process. Multilayer rolled products are thus produced. The products produced are suitable for high pressure vessels and pipes, but not for shells loaded with pressure from the outside. A cross-sectional photograph of a 9-layer quasi-laminar sheet of 09G2SF steel (18 mm thick) is presented. The quasi-laminar materials can also be produced by autovacuum welding under pressure, first used in the production of bimetallic strips. This method allows both hot and cold deformation to be used to produce the multilayer products. Figures 3.
[144-6508]

THIN FILMS

UDC 539.216.2:669

ELECTROPHYSICAL PROPERTIES OF THIN TANTALUM, NIOBIUM AND TITANIUM FILMS BOMBARDED BY NITROGEN IONS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81 (manuscript received 20 Jul 78) pp 12-17

BELYY, I. M., KOMAROV, F. F., PIL'KO, V. V. and YANKOVSKIY, V. M., Minsk

[Abstract] An experimental study of the ion-beam process was made to determine how the structure, composition, and properties of thin transition metals (Ta, Nb, Ti) can be controlled by implantation of nitrogen ions. Film specimens for this study were deposited on ST-50/1 pyroceramic substrates with an ion spray gun, at a rate of 90-120 Å/min to a total thickness of 400±20 Å, initially under a vacuum of $1.33 \cdot 10^{-4}$ Pa and subsequently in a pure argon atmosphere under a pressure of $9.3 \cdot 10^{-2}$ Pa. These films were then bombarded with 60 keV N_2^+ ions, the dose varying from 10^{20} to $5 \cdot 10^{21}$ ions/m^2, with an ion current of 0.2 A/m^2 and a voltage of 2-3 kV at the target. The electrical layer-resistivity was measured with a Tesla bridge at temperatures from -196 to +200°C and the Hall constant was measured by the standard compensation method in a magnetic field of 0.876 MA/m intensity. The dependence of electrophysical properties, including also the charge concentration and the layer mobility, on the bombardment dose was established. The electrical layer-resistivity was found to be a nearly bilinear, approximately exponential, function of the N_2^+ dose for tantalum and niobium, slightly peaking first and then decreasing in the case of titanium. The trend is attributed to a dissolution of nitrogen and its entering the interstices in the metal lattice, where its atoms push the metal atoms farther apart. Bombardment with small doses up to $5 \cdot 10^{20}$ ions/m^2 thus causes radiative defects and produces a solid solution, while bombardment with large doses above 10^{21} ions/m^2 produces a new nitride phase with different levels of defectiveness in the metal and nonmetal sublattices. Figures 5; references 7: 5 Russian, 2 Western.
[154-2415]

TITANIUM

UDC 669.295-112

IMPROVING CHARACTERISTICS OF TITANIUM POWDER PRODUCTS

Moscow TSVETNYYE METALLY in Russian No 7, Jul 81 pp 65-67

ANOKHIN, V. M. and OGNEV, R. K.

[Abstract] A comparative study and evaluation of titanium powder processing methods continues, so that further recommendations can be made on how to improve the technical economic characteristics of titanium powder products. Electrolytic powder has a higher density and a better pressability, while sponge tailings have a larger specific surface and a better formability. Both can be pressed at room temperature or sintered under vacuum. Extrusion and hot stamping of electrolytic powder has also been found to be feasible. The mechanical properties, particularly the wear resistance, are significantly improved by alloying the titanium powder with refractory metals or compounds. This has been confirmed by friction tests for 10^7 cycles under pressures of 0.5 and 1 MPa, sintered titanium against 12KhN3A steel, each type of alloying compound (0.8 V_2O_5 + 0.5 TiH_2, 0.6 ZnO + 0.5 TiH_2, 2Al_4C_3, 2ZrC, TiC, VSi_2, $MoSi_2$, 1ZrN, 2TiB_2) in the titanium matrix differently affecting the surface layer of the steel part: metal oxides, for example, acting as solid lubricants. Porous titanium products are also finding wider applications as cloth, felt, and mesh for filters, especially in the food industry where their high corrosion resistance and biological neutrality are highly desirable features. Where conventional manufacturing methods fail here, new techniques are being developed for producing both tubular and sheet stock of poruus titanium. These developments have an appreciable positive impact on the entire national economy. References 5: all Russian.
[158-2415]

UDC: 669.295

OXYGEN CONTENT IN SPONGE TITANIUM

Moscow TSVETNYYE METALLY in Russian No 6, Jun 81 pp 72-74

TITARENKO, A. I., ALEKSANDROVSKIY, S. V., CHEREPANOVA, Ye. A.,
ZAKHAREVICH, A. A. and LABUNETS, T. B.

[Abstract] A study is made of the distribution of oxygen transferred from return condensate in products of the magnesium-reduced production process on industrial apparatus using the stable isotope oxygen 18 in the form of heavy-oxygen water. The heavy-oxygen water ($H_2{}^{18}O$) was poured into a distributor, a sealed vessel with a tube used to feed argon and supply three sprayers. The return condensate from the industrial process used in the experiment was not passivated. As the argon was fed in, the water was sprayed as a fog into the surrounding space in the retort for 5 minutes, then after 30 minutes of holding the apparatus was rapidly sealed with another cover and placed in the reduction furnace, then evacuated for 3 hours without heating, then heated to 500°C, after which the reduction process continued according to the normal technology. The experimental data produced showed that over 80% of the oxygen introduced with the condensate was removed upon vacuum drying before the process, about 20% of the oxygen remaining and being distributed in the condensate magnesium, titanium sponge and the condensate of the subsequent separation process. The data indicate that when the condensate is dried with an outer wall temperature of the apparatus of 400°C for 1 hour (temperature on surface of condensate 190°C), the content of oxygen 18 is significantly reduced in all categories of sponge titanium in comparison to drying at 500°C. The experiments showed that oxygen is transferred from the return condensate after it is dried in the apparatus before the process into the sponge titanium. Vacuum drying of the return condensate can reduce the contamination of the sponge titanium produced by about 30%, but even under these conditions over 20% of the oxygen from the return condensate is transferred to the sponge titanium.
[152-6508]

UDC: 669.295

CLASSIFYING TITANIUM SLAGS

Moscow TSVETNYYE METALLY in Russian No 6, Jun 81 pp 74-75

TSVETKOV, V. V., KIPRICH, N. A. and REZNICHENKO, V. A.

[Abstract] Titanium slags are an artificial raw material for the production of metallic titanium, its white pigment and oxides of vanadium (V) and niobium (V). The authors distinguish titanium slags as an independent new class of chemical compounds. The constant presence of magnesium oxide and the possibility of broad development of a special kind of isomorphism (nonstoichiometry) provides a basis for development of a classification of magnesium artificial titanates, essentially supplementing the general systematization of titanium slags. One example of nonstoichiometry of magnesium titanates is the dissolution of magnesium metatitanate in the lattice of magnetite. A classification is presented in a table, including 5 groups of titanates combined by the presence of structural TiO_6 complexes and configurations of electrons forming a chemical (hydride) bond. A large number of mineral species of stoichiometric and nonstoichiometric composition (solid solutions) are included. The data presented also indicate that titanomagnetite may be a complex solid solution, a type of mineral. Under certain conditions, particularly during heating, the titanomagnetite concentrate undergoes complete recrystallization, forming two solid solutions: ulvospinel in magnetite and ilmenite in hematite. Titanomagnetite must therefore be taken to mean not only a natural mechanical mixture of magnetite and ilmenite, but also artificial minerals, solid solutions of hematite in ilmenite, ulvospinel in magnetite and high temperature solid solutions of geikielite in magnetite. [152-6508]

UDC: 669.295:621.791:052:620.18

INFLUENCE OF STRUCTURE ON MECHANICAL PROPERTIES OF WELDED JOINTS OF VT6 TITANIUM ALLOY

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 81 (manuscript received 6 May 80) pp 171-184

GRIDNEV, V. N., ZAMKOV, V. N., KUSHNAREVA, N. P., TREFILOV, V. I., TURTSEVICH, Ye. N. and SHEVELEV, A. D., Kiev

[Abstract] Studies were performed on 55-mm-thick plates cut from a forging. Welding was performed with the following parameters: accelerating voltage 60 kV, current 430 mA, welding speed 56 m/hr. The seam width varied little over the height of the specimen, 3--3.5 mm. Welded specimens were annealed in a vacuum furnace at $1 \cdot 10^{-5}$-$2 \cdot 10^{-6}$ mm Hg. The cooling rate was 2 to 3° per minute. Two annealing temperatures were used, the usual 750°C for 2 and 48 hours, as well as 1020°C for 2 hours. Structural studies were performed by transmission electron microscopy. Electron micrographs and graphs of the temperature variation of logarithmic decrement and shear modulus are presented. It is found that deformation of the α phase results not only from slipping but also from twinning. Three cases of stress relaxation and interphase boundaries are observed: 1) slip lines arising in the α phase passing freely through neighboring β plates, causing shear; 2) stresses at the tip of a stagnated twin not relaxed by crystalline shift, but rather causing the formation of a crack in the β phase; and 3) a crack arising in the β phase is fully localized within it, since the stresses at the tip are relaxed in the α area. These phenomena are explained by the presence or absence of interphase interlayers at the α and β phase boundary. The optimal combination of properties is noted after annealing of the

welded joints at 750°C for 48 hours. This is related to further plasticizing of the α phase as a result of the formation of finely dispersed segregations. The width of the special interphase layer formed at the division boundary of the α and β crystals varies in the process of heat treatment. Oxygen in the β phase is presumed to be partially localized with vanadium atoms. Figures 5; references 28: 13 Russian, 15 Western.
[144-6508]

UDC 539.4

EFFECT OF RESIDUAL STRESSES ON FATIGUE RESISTANCE OF VT9 TITANIUM ALLOY AT VARIOUS TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 81 (manuscript received 14 May 79) pp 33-37

BALASHOV, B. F., PETUKHOV, A. N. and ARKHIPOV, A. N., Central Scientific Research Institute of Aircraft Engines imeni P. I. Baranov, Moscow

[Abstract] A study was made of the effect of residual stresses on the fatigue strength of the VT9 titanium alloy. Smooth specimens 7.5 mm in diameter and specimens with circular notches (theoretical 2.0 stress concentration factor in flexure) were produced from ingots with three different microstructures: equiaxial, basket-weave, course-acicular, They were tested in symmetric flexure with rotation at a frequency of approximately 90 Hz, with the temperature varied from 400 to 550°C in 50°C steps. Here the data are evaluated to indicate how surface hardening by cold working with a roller, with metal balls, or glass balls and relaxation of residual stresses by raising the temperature affect the fatigue strength of smooth specimens and of the stress concentration zones in specimens with notches on 10^6, 10^7, and 10^8-cycle bases. In the case of smooth specimens the effect of surface hardening is still retained at 500°C on a short base, but the fatigue strength decreases on a long base. In the case of notched specimens under axial elastoplastic compression, on the other hand, residual tensile stresses increase the fatigue strength by 10-20% on almost any base at 500°C and lower it by 25-45% at normal temperature. Also the Bauschinger effect and acceleration of "cold" creep were found in the latter case. Figures 3; references 7: all Russian.
[160-2415]

UDC: 669.295:621.785.532:620.17:620.18

INFLUENCE OF NITRIDING ON STRUCTURE OF SURFACE LAYERS AND PROPERTIES OF AT3 AND AT6 TITANIUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, Jul 81 pp 47-50

BORISKINA, N. G., SHASHKOV, D. P., KENINA, Ye. M. and MIKHALIN, V. M.

[Abstract] A study was made of the alloys AT3 (2.7% Al, 0.2% Fe, 0.28% Cr, 0.24% Si, 0.02% C, 0.16% O, 0.03% N, 0.005% H) and AT6 (5% Al, 0.28% Fe, 0.33% Cr, 0.29% Si, 0.03% C, 0.08% O, 0.02% N, 0.007% H) after nitriding under various conditions. Specimens of type VT1-0 titanium alloy were simultaneously nitrided for comparison. Nitriding was performed in purified nitrogen at atmospheric pressure in a quartz tube resistance furnace at 900-1000°C for 1 to 10 hours. The specimens were cooled in a stream of nitrogen to 100°C, then removed from the furnace. The depth of penetration of the nitrogen was determined by measurement of microhardness; the mechanical properties of nitride in specimens were determined in extension at 1.5 mm/min. All specimens were light yellow after nitriding, indicating the formation of TiN on the surface. Microstructural analysis showed that the structure changed from the surface toward the center in basically the same manner for all specimens. The alloys AT3 and AT6 were found to have deeper diffusion layers than titanium. The thickness of these layers increased with an increase in aluminum content. Nitriding at 900 and 1000°C decreases the plastic properties of titanium and alloys, particularly AT3. Nitriding in pure nitrogen increases the wear resistance of both alloys by a factor of 2 to 3. References 4: all Russian.
[147-6508]

UDC 620.194

PRONENESS OF WELDED JOINTS OF A TITANIUM ALLOY TO STRESS-CORROSION CRACKING IN A CHLORIDE SOLUTION

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 17, No 3, May-Jun 81 (manuscript received 26 Dec 80) pp 113-115

BLASHCHUK, V. Ye., SHELENKOV, G. M., KOVAL', M. V. and MELEKHOV, R. K., Physico-Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, L'vov

[Abstract] A study was made to determine the proneness of welded joints of the AT3 titanium alloy with a stress concentrating fatigue crack at the center of the seam to stress-corrosion cracking in a 3% NaCl solution. Specimens were cut from 20-mm-thick plates and welded together either by conventional methods (automatic and manual) or with electromagnetic stirring of the melt. Such stirring appreciably reduces the hydrogen concentration and slightly increases the oxygen concentration in the seam metal. Electromagnetic stirring was found to improve the resistance to stress-corrosion cracking of the seam metal in welded joints made automatically without separation of edges and without a filler, namely to increase the stress intensity coefficient in both short (1 min till fracture) and long (2000 hr) tests, but not in joints produced manually with a filler and with or without separation of edges. With electromagnetic stirring, moreover, there was hardly any difference found between the characteristics of the base metal and those of the seam metal. Figures 1; references 4: 2 Russian, 2 Western. [157-2415]

UDC: 621.791:621.7.044.2

INCREASING BRITTLE FRACTURE RESISTANCE OF WELDED JOINTS FOLLOWING EXPLOSIVE TREATMENT

Kiev AVTOMATICHESKAYA SVARKA in Russian No 6, Jun 81 pp 70-71

PETUSHKOV, V. G., ZHDANOV, I. M., candidates of technical sciences, and KASATKIN, S. B., engineer

[Abstract] A study is made of the influence of explosive treatment on the specifics of development of brittle fracture from the tip of a transverse notch, imitating a crack-like defect. Three types of flat specimens of St3sp steel 9 to 10 mm thick with gage section dimensions of 250 x 120 mm and a central transverse notch 25 mm long with a tip radius of 0.1 mm were studied: specimens of the base metal, specimens with surfacing on one side after the notch was made, and specimens with surfacing treated by explosion at the tip of the notch so as to reduce residual stress. At $T = -20°C$, σ_n was approximately the same for all types of specimens and significantly greater than the yield point of the base metal at that temperature. At $T = -40°C$, type II specimens showed a tendency toward brittle fracture. Further reductions in temperature caused a significant decrease in the net stress for type II specimens and a slight decrease in net stress for the other specimens. The critical temperature for brittle fracture was found to be -40°C for type II specimens, lower than -70°C for the other two types. Figures 1; references 3: all Russian.
[145-6508]

UDC: 621.791.72.052:669.715:539.4

FATIGUE RESISTANCE OF ALUMINUM ALLOYS AMg6, AMg6N, 1201 AND THEIR JOINTS MADE BY ELECTRON BEAM WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 6, Jun 81
(manuscript received 17 Nov 80, in final form 23 Dec 80) pp 40-42

BONDAREV, A. A., candidate of technical sciences, Ye. O. Paton Institute of Electric Welding, Ukrainian Academy of Sciences

[Abstract] The purpose of this work was to determine the fatigue resistance of base metal and welded joints in AMg6, AMg6N and 1201 alloys welded by electron-beam welding. The results of the study can be used for comparative estimation of the fatigue strength of these materials for this welding method. The composition of the alloys was as follows: AMg6, 200 mm diameter x 22 mm pipe: Mg, 6.1%; Mn, 0.59%; Ti, 0.055%; Fe, 0.18%; Si, 0.24%; Zn, 0.20%; AMg6N, slab: Mg, 6.0%; Mn, 0.58%; Ti, 0.060%; Fe, 0.14%; Si, 0.13%; Zn, 0.18%; AMg6, 1.2 mm diameter wire: Mg, 6.3%; Mn, 0.63%; Ti, 0.050%; Fe, 0.10%; Si, 0.100%; 1201, slab: Mg, 0.01%; Cu, 6.0%; Mn, 0.25%; Zr, 0.083%; Fe, 0.10%; Si, 0.065%. The specimens were tested in symmetrical flexure with rotation on a UKI-10M machine, loading rate 3000 cycles per minute, maximum test base $2 \cdot 10^7$ cycles. Specimens with a circular notch were used to estimate the influence of stress concentrators. It was found that the fatigue strength of welded joints for materials without stress concentrators is practically independent of the initial state of the material before welding. The endurance limit of joints in 1201 alloy without stress concentrators is higher than that of the other alloys. The stress concentrator levels out the endurance limits of the metals tested and decreases the limit in comparison to smooth specimens. Figures 1; references 3: all Russian.
[145-6508]

UDC: 621.791.09:621.785

NATURE OF FRACTURE OF WELDED JOINTS OF HEAT RESISTANT NICKEL ALLOYS UPON HEATING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 81 p 27

MOROCHKO, V. P., ZHEGINA, I. P. and SOROKIN, L. I., candidates of technical sciences

[Abstract] In order to determine the reasons for failure of joints during heat treatment, the authors studied the nature of the propagation of cracks in a joint by studying fractures. The material was dispersion-hardened nickel-based KhN73MBTYu (EI698) alloy. After heat treatment, longitudinal and transverse cracks were found around the seam. Analysis of the fracture showed that regardless of the placement of the crack they usually extend through the entire cross

section, in the seam and in the base metal with the fracture plane perpendicular to the surface of the specimen. Apparently the brittle nature of the fracture of a welded joint during heat treatment depends on the presence of particles of an intermetallic phase which can be separated at grain boundaries. The fractographic studies thus establish that the failure of welded joints in heat resistant nickel alloys upon repeated heating occurs throughout the entire cross section. When failure occurs along the seam and base metal, it has a brittle intergrain nature, while when failures occur through the near-seam zone there are traces of plastic deformation along the grain boundaries. Figures 1; references 2; both Western.
[165-6508]

UDC: 621.791.72:621.791.052:620.17:669.295

MECHANICAL PROPERTIES AND STRUCTURE OF WELDED JOINTS OF VT23 TITANIUM ALLOY MADE BY ELECTRON-BEAM WELDING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 81 pp 25-27

KHOREV, M. A., IODA, A. V. and KRASNOZHON, A. I., engineers

[Abstract] Electron-beam welding, capable of joining parts with cross sections of up to 100 mm and more, is quite promising for replacement of mechanical joints in large cross section parts with welded joints. A study was made of the influence of vacuum heating to 600-900°C (10^{-3} mm Hg) and subsequent cooling at 3-5°C/min on the mechanical properties of welded joints. The results of analysis of the hardness of the metal both of the seam and of the transition zone, as well as the base metal, showed that in the 600-950°C zone as the annealing temperature rose into the $\alpha+\beta$ area up to 880°C, the hardness of all zones of the welded joint decreased. The welded joint was softened to the greatest extent. Increasing the annealing temperature to 950°C results in an increase in hardness and in strength. Heating to 650°C with subsequent rapid cooling in air provides less strength but greater impact toughness. Maximum impact toughness is achieved by heating to 880°C and cooling with the furnace. Maximum strength is achieved by heating to 780°C with subsequent aging at 550°C for 10 hours. Figures 5; references 2: both Russian.
[165-6508]

UDC 621.791:65.011.53-54:658.5.011.46

ASPECTS OF COST EFFECTIVENESS ANALYSIS OF NEW MECHANIZATION AND AUTOMATION EQUIPMENT FOR WELDING INDUSTRY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 81
(manuscript received 20 Oct 80, after final revision 24 Nov 80) pp 60-62

CHVERTKO, A. I., doctor of technical sciences, TIMCHENKO, V. A., candidate of technical sciences, SNEZHKO, V. I., engineer, and ARTYUKHOVSKAYA, N. I., engineer, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences

[Abstract] The three steps in planning the introduction of new equipment (comparison with existing equipment, comparison between possible alternatives, and selection of the optimum variant from the standpoint of maximum effectiveness) are applied to mechanization and automation equipment for the welding industry. The economic criterion in any of these steps is the minimum production cost. All the components of this cost are examined here as they apply to the welding process. A straight break-even line, decrement of production cost versus increment of capital investment cost, is established which defines the boundary between economical and uneconomical equipment. Figures 1; references 3: all Russian.
[173-2415]

UDC 621.791.052:539.4:014:669.017.3

EFFECT OF TEMPORARY WELDING STRESSES IN 30KhGSNA STEEL ON CHARACTER OF AUSTENITIC TRANSFORMATION AND ON RESISTANCE OF THERMAL INFLUENCE ZONE TO COLD CRACKING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 81
(manuscript received 3 Nov 80, after final revision 20 Jan 81) pp 8-12

LEBEDEV, Yu. M., candidate of physico-mathematical sciences, and DANILYUK, N. M., engineer, Nikolayev Institute of Ship Building, STERENBOGEN, Yu. A., doctor of technical sciences, GORDONNYY, V. G., candidate of technical sciences, and NOVIKOVA, D. P., candidate of technical sciences, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences

[Abstract] A study of transformations in 30KhGSNA steel due to thermal stressing cycles was made by heating clamped tubular specimens at an average rate of 150°C/sec to 900°C and cooling them at rates from 0.9 to 60°C/sec through the 550°C temperature. The temperature-time diagrams of thermokinetic austenite breakdown and microstructural examination after a cycle, correlated with the oscillatory variation of stresses with decreasing temperature, indicate that heating to 900°C and subsequent cooling at 1°C/sec causes pearlitic and

bainitic as well as martensitic transformation to occur. Increasing the cooling rate to 2.3°C/sec changes only the quantitative proportions of the transformation products, and increasing it above 10.5°C/sec results in a martensitic transformation only (beginning at 450°C--ending at 100°C). Elastoplastic stresses and strains are found to raise the temperatures of the beginning of martensitic and bainitic transformations while also widening the temperature ranges of both. Specimens were welded in a 550-600 A - 30-32 V - 18 m/hr mechanized process with AN-15 flux, joints being made with ferritic-pearlitic seam metal (Sv-10KhGSN2MT rods) and with pearlitic-bainitic seam metal (Sv-20Kh4MA rods). Increasing the alloy content in the seam metal was found to improve the characteristics of the thermal influence zone and its resistance to cold cracking. Increasing the tensile stresses up to 100-150 MPa at temperatures from 450 to 420°C shifts the austenite transformation temperatures by as much as 30°C upward and also improves the resistance to cold cracking appreciably. Figures 6; references 12: all Russian.
[173-2415]

UDC 621.791:669.14.018.29-419

LAMINATED STEEL FOR WELDED STRUCTURES

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 81
(manuscript received 19 Dec 80, after final revision 7 Apr 81) pp 1-4

PATON, B. Ye., academician (USSR Academy of Sciences), MEDOVAR, B. I., academician (UkSSR Academy of Sciences), SAYENKO, V. Ya., candidate of technical sciences, KRENDELEVA, A. I., candidate of technical sciences, and POSTIZHENKO, V. K., engineer, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences

[Abstract] Data are presented on the development of laminated steel for welded structures, layers of the low-carbon low-alloy 09G2SF reel steel variously interspersed with layers of the M76 rail steel. A study was made to determine the dependence of the tensile strength and the yield point as well as of the technological processability and the weldability in an arc pool on the total fraction and the distribution of M76 layers in the stack. Stacks were tested in the hot-rolled state as well as after heat treatment for rail steel (normalization at 900°C or oil quenching from 830°C with subsequent tempering at 450°C for 2 hrs), a specimen of 09G2SF steel alone in a 16-mm-thick stack of 17 layers serving as reference and control. Interlayers of M76 steel were found to increase the yield point and the tensile strength of hot-rolled stacks respectively by 10% and 15-35%, on the average, of normalized stacks respectively by 20 and 30%, and of quenched and tempered stacks respectively by 20 and 40% with 42-48% M76 steel (no increase with up to 20% M76 steel). The weldability of hot-rolled heterogeneous stacks was tested with Sv-08GNM rod and An-60 flux in a 950 A - 48-50 V - 42 m/hr process. The results were positive. Only with 48% M76 steel did the hardness of the material increase within the overheat zone, which could cause cracking near the seam. Figures 7; references 9: all Russian.
[173-2415]

MISCELLANEOUS

EFFICIENT EXPLOITATION OF KURSK MAGNETIC ANOMALY URGED

Moscow EKONOMICHESKAYA GAZETA in Russian No 30, Jul 81 p 5

[Article by V. P. Sobolev, secretary of the Belgorodskaya Oblast CPSU Committee: "To Utilize Efficiently the Riches of the Kursk Magnetic Anomaly"]

[Text] One of the country's largest territorial-production complexes, based on the mineral resources of the Kursk Magnetic Anomaly, is being established in Belgorodskaya Oblast, by the will of the party and people. Its establishment is proceeding in parallel with the establishment of like complexes in other areas of the European part of the RSFSR, in the Urals, Siberia, the Far East, in Kazakhstan and Tadzhikistan. Discussing these complexes in his report at the 26th CPSU Congress, L. I. Brezhnev stressed: "All this is a result of the party's far-sighted policy. All this is a result of courage and enthusiasm on the part of workers, engineers, technicians, and scientists who, working in difficult, at times incredibly difficult conditions, have placed extremely rich natural resources in the service of the nation's economy."

Raw Materials Base of the Complex

One of the main factors promoting growth of this oblast's economic potential was the existence of vast iron ore reserves.

The KMA [Kursk Magnetic Anomaly] basin encompasses several oblasts of the Russian Federation and the Ukraine. Approximately 90 percent of the ore reserves are located in Belgorodskaya Oblast.

In addition to iron ore, we have large reserves of clay, chalk, marls, shales, and sand. Bauxite has been discovered in recent years, as well as nonferrous metal ores. Establishment of a territorial-production complex is also promoted by an extensive network of roads and rail lines and a highly developed, densely populated territory. Basic development projects commenced immediately following the 24th CPSU Congress. As we know, the resolutions of the 25th CPSU Congress specified for the oblast party organization the task of securing further development of the complex, with construction of the Oskol Electrometallurgical Combine.

There are already three large mining enterprises in operation in this oblast: the Lebedinskiy GOK [Mining and Concentration Combine], the KMAruda Combine, the Combine imeni 50th Anniversary of the USSR, and the Stoylenskiy mine, a component of the Stoylenskiy GOK, which is presently under construction. The Yakovlevskiy mine, with ore to be mined underground, is under construction. During the years of the last five-year plan alone Belgorod miners produced and shipped 119 million tons of merchantable iron ore to this country's metallurgical plants, or 50 percent more than during the Ninth Five-Year Plan.

The increase in production capacity in the last five-year plan was achieved primarily through further construction on such large mining and concentration combines as the Lebedinskiy in our oblast and the Mikhaylovskiy in Kurskaya Oblast. Movement of the Lebedinskiy GOK on-stream was the most significant step in development of the mining industry. The new balless grinding process employed at the combine and installation of modern process equipment in the concentration mills made it possible to produce concentrate with the country's highest iron content -- 68 percent and higher, and to begin putting out a new product -- pelletized iron ore. The oblast party organization is presently mobilizing the efforts of Communists and all workers toward implementing the resolutions of the 26th CPSU Congress pertaining to further development of the territorial-production complex.

The intensive development of mining enterprises is due not only to the necessity of creating a powerful raw materials base for ferrous metallurgy in the central part of the country, but is also due to the high degree of economic effectiveness of working this basin's iron ore bodies. Calculated expenditures per ton of merchantable iron ore in the KMA are 50 percent below these figures for enterprises in Eastern Siberia, 30 percent below enterprises in Kazakhstan, 20 percent below enterprises in the Urals, and 15 percent below enterprises in the Ukraine.

Development of Basic Branches

The production capacity of the iron ore enterprises of this oblast by the end of the 11th Five-Year Plan will be 39 percent higher than the level achieved in the 10th Five-Year Plan, and will amount to almost 72 million tons for raw ore and 33 million for merchantable ore.

In addition, the percentage share of high-grade concentrate for the requirements of the Oskol Electrometallurgical Combine in the total volume figure will also grow. The first unit of the Stoylenskiy GOK, with an output capacity of 20 million tons, is scheduled to come on-stream during this five-year plan. Also scheduled is preliminary work on construction of the Chernyanskiy and Prioskol'skiy GOKs, located near the Oskol Combine.

Surface mining remains the principal mode of working iron ore deposits, but the volume of underground mining will also increase in our oblast when the Yakovlevskiy mine comes on-stream. The first unit of this mine is presently under construction, to have an output capacity of 4.5 million tons per year. This will serve in the future as a solid foundation for designing and building big mining enterprises in this region, with an annual output capacity of 20-40 million tons of high-grade ore.

A special place in the new complex will be occupied by the Oskol Electrometallurgical Combine, which has been designated an All-Union Shock-Work Komsomol Construction Project. Utilizing the latest technology, it will produce more than 8 million tons of oxidized and 5.4 million tons of metallized pellets, 4.3 million tons of steel, and more than 3 million tons of high-grade sheet, structural and merchant mill products. We should have the first unit of the combine on-line by 1985, providing the nation with high-grade Belgorod steel.

In addition, preliminary planning is in progress for constructing near Staryy Oskol an additional metallurgical plant, to produce 10 million tons of cast slabs. This promises enormous savings to the nation's economy, for millions of tons of metallurgical raw materials as well as finished products -- rolled stock, steel, and pig iron -- are at the present time being hauled thousands of kilometers, while the main customers for this metal are located alongside the immense KMA iron ore reserves.

The scale of development of the mining and metallurgical industry insistently dictates the necessity of their mutual and correct coordination with growth and development of power engineering, machine building, transportation, the building materials industry, and agriculture. When the electrometallurgical combine comes onstream, for example, the Staryy Oskol industrial zone will consume three times as much electric power as the entire oblast is currently consuming. Several power substations have already been constructed around Staryy Oskol in order to resolve this problem. Power is being fed to this area from the Voronezh Nuclear Power Station. Construction is being completed on power transmission lines from the Kursk Nuclear Power Plant. For practical purposes it will become the heart of the Belgorod Magnitka.

A considerable amount of work remains to be done on renovation of the Belgorod, Staryy Oskol, Stoylenskaya, Gubkinskaya, and a number of other rail yards.

Water is one of the most acute problems. As the complex develops, water requirements will increase severalfold, but local sources are limited. Therefore it is planned to build the Oka-Don-Oskol Canal, extending more than 300 kilometers. Billions of cubic meters of natural gas are also needed for industrial consumption by the combine and for the entire region. This problem is being resolved by construction of the Ostrogozhsk-Staryy Oskol natural gas pipeline.

Construction of this giant electrometallurgical combine is entailing the development of other interrelated branches, particularly machine building and metals-intensive industries. For this reason we have built metal structures and milling cutter plants, bridge structures plants, and a number of other enterprises. They are presently supplying their output to the combine's construction sites, while tomorrow they themselves will be receiving metal from the combine.

In connection with a substantial growth in the inventory of mining and beneficiation equipment at KMA facilities, the first unit of the Staryy Oskol Mining and Beneficiation Equipment Repair Plant has been built; a second unit at this plant is presently under construction. This facility will repair and overhaul rotary units, heavy-payload dump trucks, and railcars. The KMArudoremont Plant is being expanded in the town of Gubkin, and the largest automotive overhaul plant in the branch is in operation in Belgorod.

Problems and development prospects of the KMA territorial-production complex were discussed in detail at the All-Union Seminar "Formation of Territorial-Production Complexes -- An Important Economic Task of the 11th Five-Year Plan," held recently in Belgorod.

Problems of By-Product Raw Materials

The KMA is rich not only in iron ore but also in other commercial minerals which are mined in the process. Calculations indicate that surveyed deposits include approximately 10 billion tons of clay, arenaceous, cretaceous and crystalline rocks.

By-product raw materials have begun to be more extensively utilized in the production of wall materials, concrete, plaster, and dry mineral pigments. The Staryy Oskol Cement Plant, for example, consumes approximately 2 million cubic meters of cretaceous rocks. Approximately half a million cubic meters of rock is consumed in construction and repair of roads and ballasting rail lines, while 60 percent of average annual sand production went for fill for the reservoir dam and hydraulic spoilbank levee at the Lebedinskiy Mining and Concentration Combine. Utilization of overburden and recovery of concentration process waste has reached a figure of 15-20 percent annually. This has made it possible substantially to reduce the volume of building materials hauled in from other parts of the country and has resulted in savings of more than 15 million rubles.

At the same time the party oblast committee believes that the overall level of utilization of natural raw materials in this oblast is failing to meet the demands imposed by the 26th CPSU Congress on development of the territorial-production complex. Since exploitation of natural resources began, many millions of cubic meters of overburden suited for producing building materials and fertilizers for agriculture have gone into spoilbanks. Last year alone more than 30 million cubic meters of chalk, sand, schist, and marl out of 45 million cubic meters of overburden have been dumped onto spoilbanks.

According to the "Plan of Development and Distribution of the Building Materials Industry for 1976-1990," ratified by USSR Gosplan, silicate brick, silicate wall materials, ground chalk and lime plants are to be constructed in this oblast. However, as a consequence of lack of coordination in the actions of the RSFSR Ministry of Construction Materials Industry and the USSR Ministry of Ferrous Metallurgy, design and construction of these enterprises is being delayed. And yet even one large chalk processing combine could greatly assist agriculture of the non-chernozem zone, supplying ground chalk for liming acid soils.

Increasing attention is being drawn by bauxite, an extremely rich deposit of which -- the Vislovskoye -- was discovered near Yakovlevo and Gostishchevo. The bauxite lies above iron ore. Therefore, when a mine is constructed, both iron ore and bauxite can be extracted from the same shafts. It is possible that soon an aluminum plant will be constructed near Belgorod, and a new branch will appear in the oblast -- nonferrous metallurgy.

Conserve Chernozem

Another most important task is restoration of the fertility of agricultural acreage disturbed by mining operations. Total acreage involved in currently operating and under-construction mining enterprises is approximately 14,000 hectares, more than half of which is arable land.

Pursuant to the Principles of Land Law of the USSR and the Union Republics, topsoil on acreage involved in construction development must be removed and preserved. At the present time more than 14 million cubic meters of chernozem have been removed in this basin, but only slightly more than 5 million cubic meters have been utilized for recultivation of disturbed land and improvement of low-productivity agricultural land.

In the future the quantity of removed and preserved chernozem will substantially increase. In the Staryy Oskol area there are more than 40,000 hectares of sandy arable land which need improvement. Four years of experience in land improvement has shown that, for example, yields of grain crops and perennial grasses can be doubled or tripled, but this work is being conducted very slowly.

Problems of efficient utilization of chernozem on a large scale can be resolved only through the joint efforts of agricultural specialists, specialists in iron mining and other branches of industry. This is why we suggest creation in the KMA of a specialized organization which would deal with the entire aggregate of abovementioned activities.

These problems are so important that in our opinion an interministerial territorial commission should be set up under the auspices of USSR Gosplan, which would coordinate the activities of all ministries and agencies in the area of comprehensive utilization of the mineral resources of the KMA.

The industrial complex which is under development has also required of us a somewhat different attitude toward agriculture. Serving the growing industry of the TPK [Territorial-Production Complex], it is called upon to retain at the same time the role of major supplier of grain, meat, poultry, canned goods, and dairy products for the entire economy. Toward this end, at the beginning of the Eighth Five-Year Plan we embarked upon a firm course of policy calling for specialization and concentration of livestock raising, a decisive changeover of agriculture to an industrial basis, and adoption of industrial methods. We are seeking to ensure that this zone's agricultural production, receiving good support from the industrial enterprises and construction organizations of the KMA, grow at a priority pace, maximally supplying working people with foodstuffs. The CPSU Central Committee and USSR Council of Ministers decree entitled "On Further Development of Agriculture in the Central-Chernozem Region of the RSFSR" focuses precisely on accomplishing this task.

Party, soviet, and economic agencies in this oblast are devoting considerable attention to housing construction and provision of quality services and recreational opportunities to the miners and construction workers. In the last five-year plan alone approximately 200 million rubles in capital investment have been spent on housing-civil construction in Staryy Oskol.

The entire diversified activities of the oblast party organization are presently focusing on accelerated formation of the territorial-production complex based on the mineral resources of the KMA. Towns and factories, mines and scientific institutes, schools and outpatient clinics, palaces of culture, athletic facilities, and the highways of the territorial-production complex will become a worthy embodiment of the resolutions of the 26th CPSU Congress.

3024
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UDOKAN COPPER ORE DEPOSIT ON BAM

Moscow LITERATURNAYA GAZETA in Russian 15 Jul 81 p 10

[Article by Z. Ibragimova: "Toward the Foot of Udokan"]

> [Text] The most recent session of the USSR Academy of Sciences Scientific Council on Problems of BAM dealt with the Udokan Industrial Center and was held in the community of Chara in the northern part of Chitinskaya Oblast. In long-range plans the Udokan Mining and Concentration Combine is presently the largest facility within the zone of the Baikal-Amur Mainline.
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> The resolutions of the 25th CPSU Congress state: "Complete planning and design work on the Udokan copper deposit."

At the foot of Udokan they were discussing copper ore.

The geologist stated: "Ore body is an economic term." He explained that not every mineral discovery is elevated to the status of ore body, and such a designation is not granted immediately. Initially a mineral discovery is modestly designated a mineral occurrence location, later a show of ore, and only when there are figures available for calculation, when one can estimate economic effect taking into account transportation and mining possibilities, only then is the "location" given the official name "ore body" or "ore deposit."

He was speaking about geology as an industrial branch, the task of which is to provide sources of raw materials, and he simply refined the meaning of the professional term.

In my opinion, the definition was incomplete. I would have added that ore deposit is a socioeconomic term.

Why is this so?

Ore bodies give life to villages, towns and cities. The exploitation of new riches causes thousands of people to move to a new place of residence, complicates the diagram of population migration flows, redraws the nation's economic-geographic map and... increases the number of locations deficient in social-personal services and amenities, semi-provision of such services and amenities, and total lack of services and amenities, which by no means promotes strengthening of the prosperity of individual regions or the country as a whole.

Addition of the term "social" assumes particular significance in those cases where the requirements of the economy dictate not simply rapid -- immediate! -- exploitation of an ore body, which begins instantly, like a fire, without any decent planning preparation. Then all the bad and good points are acquired, accumulated, cognized only empirically, and if such important values as concern for the quality of a worker's life, the countenance of new cities and towns, and preservation of forest and stream for future generations burn up in this "fire," we merely shrug our shoulders: we didn't have time for that, for we were in a hurry....

But can all disproportions which almost inevitably occur when organizing the extraction of raw materials from new sources be ascribed to the "conflagrational manner" of development and exploitation?

Let us talk about Udokan. For various reasons this ore deposit's hour is still being postponed, while geologists, designers and economists have been working on it for quite some time, and this situation of "active mothballing," if I may use that expression, permits us to look into the barely visible processes of occurrence of certain phenomena which we usually encounter at later stages, during full-swing development, when practical activities have carved a channel, by no means the best one -- from a reasonable position.

For those who know nothing about Udokan, the Udokan copper ore deposit was discovered in 1949 by geologist Yelizaveta Ivanovka Burova. It was acknowledged to be a very large ore body, of world class. Located in the northern part of Chitinskaya Oblast, in the central, highest part of the Udokan Range, in Kalarskiy Rayon, where the rails of the Baykal-Amur Mainline are to join. (Emissaries from the Ukraine, workers of the Detachment imeni 26th CPSU Congress, who joined the BAM labor force this spring, dream of "driving the golden spike with a silver hammer").

There is great natural beauty in the Chara River valley, along which copper mountains brood in silence. In silence? Alongside the Udokan runs the Kodarskiy Range, and in some years scientists record up to 170 earth tremors in a week's time in this area. Viktor Prokop'yevich Solonenko, famous Siberian seismologist and a corresponding member of the USSR Academy of Sciences, who has studied the seismicity of the Udokan region for 20 years, states that the Kodar-Udokan section is the most active in the Baykal rift zone. And according to one of the legends (there are a great many legends about these mountains, about the capricious stream, and about the perched lakes in the massive gray cliffs), two fairy-tale heroes -- Kodar and Udokan -- found a treasure and were unable to divide it peaceably. Both of them perished in a bow-and-arrow duel, but tall mountains rose up on the spot where these legendary heroes fell, and people can still hear the beating of their hearts, which causes the mountains to shake, setting loose avalanches, which tumble downward with an ominous roar.

r those who know something about Udokan, yes, you are right: for quite a few years now there has been planning, prospecting and surveying in progress on the future Udokan Mining and Concentration Combine, and journalists have already on numerous occasions called Chara the "copper capital" of the BAM, not only because it is an attractive settlement but primarily because the future combine is to process tens of millions of tons of ore each year. Exploitation of Udokan is greatly complicated by transportation conditions, or more precisely by a lack of transportation, the absence of any access roads to the copper mountains, with the exception of the almost 700-kilometer Mogocha-Chara winter road, which veteran Siberian truck drivers have long since christened the "sinister road." (The planners calculated that construction of the combine by the motor road would be from three to four times as expensive as along the rail line). But it is not only a lack of roads which has postponed the hour of Udokan. The Talnakh ore body was discovered at the beginning of the 1960's, which for a certain period of time lessened the acuteness of the problem of obtaining copper ore. Talnakh gave Noril'sk a second wind, and the Transbaykal "copper capital" wandered from current plans, from tactical tasks to long-range plans, to strategic tasks. "Udokan is the strategy of Soviet nonferrous metallurgy," Mintsvetmet [Ministry of Nonferrous Metallurgy] decided and insisted on completing a survey of the ore body. The timetables of the planning projects were extended.

For those who know everything about Udokan.

...But do such exist? I met for the first time the chief engineer of the Udokan Mining and Concentration Combine project seven years ago, at a conference in Bratsk on the development of Siberia in the 10th Five-Year Plan. At that time Vladimir Vasil'yevich Popkov spoke with confidence and inspiration about the future GOK [Mining and Concentration Combine], and it seemed that here was a man who knew everything about Udokan: everything about the ore itself, everything about the ore treatment processes, and everything about the economics of exploiting difficult-access riches. Seven years have passed. Popkov presents a report at a scientific council, and the tone of this report differs considerably from past reports. This report is filled with statement of problems and lists problems with multiple-variant solutions.

I could not help but ask: "Vladimir Vasil'yevich, seven years ago did you know more about Udokan than you do today? Is my impression wrong?"

The project chief engineer smiled in reply: "That's a fact. These past years have introduced substantial corrections into our previous notions. In the first place, thanks to additional exploration and survey we obtained totally new information on the ore body. The geologists have explored new areas, and ore has been discovered where previously it had not been assumed to be found. In the second place, due to semicommercial-scale tests, new information was obtained on the processing features of these ores, their flotation capability, etc. Thirdly, the course of life itself alters input economic information: vehicles and equipment become more expensive, and this has an appreciable influence on certain decisions. Fourth, the requirements on mining operations have changed. In particular, a Law on Conservation of Mineral Resources has been passed, which imposes new, more stringent demands on miners. (In the past, for example, we would dump beyond-balance ore together with the waste rock, and nobody would complain about it, but now we must stockpile this ore). In other words, we of course know much more today than we did in the past (incidentally, I should recall that the Udokan ore body figured in the resolutions of the 23d CPSU Congress), but our tasks do not become easier because of this. I can state emphatically, however, that the more you work 'on an ore body,' on any problem, the greater the chances of arriving at optimal solutions. The solutions we incorporate into the project today are incomparably better than yesterday's. The fact is that today we have equipment about which we didn't even dream in the past!"

"But this process is a process of progress, if you will excuse the clumsy expression -- an endless process, and considerable funds have been invested in planning, prospecting and surveying activities. You stated a figure of more than 20 million...."

"And these expenditures are justified!" Viktor Arkad'yevich Smirnov, chief engineer of the Soyuzmed' All-Union Production Association, vehemently interjected. "The point is not at all the fact that we are sitting at the foot of Udokan and waiting for some technological revolution maximally to ease our task of conquering it. We believe that one should approach such a complex project with open eyes. Objectively the situation developed so that we were given time to gain deeper knowledge about the ore body. We cannot permit at Udokan a substantial increase in the cost of facilities in comparison with preplanning estimates -- unfortunately these are no rarity in nonferrous metallurgy as well. It is a very good thing, for example, that we were able to give the geologists an additional assignment: detail the distribution of ore grades. Where are their boundaries? What will we encounter during the first years of operation? What will we encounter 10 years hence? And they gave us answers to these questions. Tests also cleared up many points."

Vladimir Stepanovich Chechetkin, chief geologist of the Udokan geological survey expedition, confirmed: "Yes, we are proceeding to this ore body with open eyes."

And are there people who know everything about Udokan? Of course not. The geologists are still working on the program which is scheduled for completion in 1985. Process engineers are still discussing a great many items which require both theoretical elaboration and experimental verification. Planners are looking carefully into ore transfer equipment development solutions.... But nevertheless, as regards the industrial aspect of Udokan, at any rate they have an idea of where efforts should be focused during the years prior to commencement of construction of the combine.

But what facilities will there be alongside the combine? The mining engineers promise a modern town with all the comforts and amenities. Who will be living in this town?

A foolish question, right? It is obvious who will be living there. Initially it will be primarily construction workers, and later miners, power engineers, repair and overhaul personnel, transport workers, mechanics, etc. But does anybody have a clear idea of the structure of the future town?

"In my opinion this problem has been ignored by the scientists," states Doctor of Geographic Sciences Aleksey Aleksandrovich Nedeshev, head of the Chita Regional Laboratory of the Institute of Geography of Siberia and the Far East of the Siberian Department of the USSR Academy of Sciences. "And not only the scientists. So much is being said about basic production -- and almost nothing about all the rest. And yet even initial calculations make a very strong impression, I would even call them a revelation. Here is a figure: 8 percent of the personnel at this industrial center will be engaged in mining copper. All the rest will be in a support configuration around the miners. Generally speaking, this is not an unusually high ratio: Siberian economists figure that the coal at Neryungri is being mined by 5 percent of the workers in that town, and oil in Western Siberia by 2 percent. There is nothing bad about these figures proper. On the contrary, they can be viewed as an indicator of a high level of mechanization of basic production. The bad thing is that nobody is working seriously either on the question of auxiliary production or the service area. The impressions one gets from new Siberian development projects are as a rule conflictive and of the same type: excellent equipment, outstanding modern hardware -- and primitive meal facilities, primitive manual unloading of goods in the retail stores, and an unhurried female employee at the post office, haughtily dressing down the impatient line: 'Can't you see that I am gluing, stamping the postmark and tying parcels?' In short, a primitive operation.... As if no technical advances have touched these sectors! At new construction projects old -- and the worst -- models are copied with amazing persistence, and one can easily figure what this is costing the state if one considers the fact that we are dealing with regions in which the cost of maintaining each worker is much greater than in established, developed areas.

"Have you visited Neryungri, the young coal-mining town in Southern Yakutia? If you do visit it, take note of the fact that there are practically no people in the strip-mining area, except for those operating the huge equipment, 180-ton dump trucks or 20 cubic meter excavators. The town is full of people, a town which has grown up by the mine and for the mine. And in Tynda, capital of BAM, young Tynda, two years ago the chief of police was complaining... about parasites, who are causing the police a lot of problems. Why are there parasites at a new development project? Why are they here and not in easy-living resort areas, where the weather itself protects idlers? Why are they in this harsh land, where it is primarily workers who are needed?"

A lack of attention toward auxiliary operations and the service area... guarantees work at new construction projects for all comers -- including the most unskilled persons. A mining town grows like mushrooms after a rain. There is a place here not only for a first-class mining engineer but also an idler without any work skills, who possesses little physical strength, for which the state is willing to pay him twice, three times, four times as much as anywhere else, and only because the town's developers focused their mental efforts only on the main production operation, which employs the services of marvelous machinery, marvelous continuous-flow lines, and outstanding specialists.

...Udokan's time is not yet near. But while the experts possess more or less complete information on ore grades, nobody can say anything definite about the social structure of the population of the future town. It is a matter here not only of open eyes. It is a matter of taking a sharp gaze so far into the future that one would do better to take a pack of cards and let the cards tell what has been and what will be.... But we do not need the cards to tell us what has been -- we know from the experience of other ore bodies. We know the cost of a high rate of labor turnover, and we know the price of instability of professionally-qualified work forces, low labor productivity, and a high percentage of low-skill labor.

I heard in the halls of the Scientific Council confirmation of my own thoughts: "Of course the planners and engineers will be held fully to account for the basic production and for ore treatment, but nobody will say a single word about loading and unloading, meal distribution, or a boiler house in place of an electric power plant."

Perhaps it is a good thing that they are talking not only about ore at the foot of Udokan.

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NUCLEAR METALLURGICAL COMPLEX AS NEW PROBLEM SOLUTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 4, Jul-Aug 81 (manuscript received 9 Mar 81) pp 5-9

[Article by A. I. Manokhin and V. A. Legasov: "YaMK -- New Solution to Problems of Metallurgy"]

[Text] In all times producing iron involved utilization of organic reducing agents, while the technology was such that it inevitably depleted and polluted the environment. Today's technology is also based on rapidly-consumed reserves of coking coal and natural gas. The metallurgical industry is a major consumer of fossil fuel. Approximately one fourth of all fossil fuel, including such a short-supply type as coking coal, is expended by man on producing iron and steel.

Fossil fuels are non-renewable resources, and in addition the combustion of fossil fuels in metallurgical equipment pollutes the environment, while the metal obtained from ore must be purified of the contaminants entering it from the coke.

The multiple-stage nature of the process constitutes a significant drawback of the present technology of obtaining iron. When extracting iron from ore by the blast-furnace process, we obtain an intermediate product -- pig iron -- which is an alloy of iron and carbon. It is only later, after removing carbon by oxidation (open-hearth and converter processes), that we obtain iron in pure form as a basis for producing various steels and alloys. Carbon monoxide, sulfur compounds, and oxides of iron, formed as by-products in the burning out of carbon, are ejected into the atmosphere as pollutant waste products. And yet iron occurs in nature in the form of oxides Fe_xO_y, and during the extraction of iron we should also obtain a second constituent -- oxygen. No such industrial processes yet exist anywhere in the world, however. Realization of such a process is one of the principal tasks of future metallurgy. It is also quite clear that an optimal process should be based on a more abundantly-occurring reducing agent -- hydrogen -- should have fewer intermediate cycles, and should ensure waste-free production of metals. With the development of nuclear power engineering there naturally arose the idea of achieving partial or total elimination of consumption of coke by introducing into the metallurgical complex the heat from a high-temperature nuclear reactor, for example. Let us see, however, what temperatures are employed in today's metallurgical industry. Temperatures reach 1500°C during the production of pig iron, 1700°C during the production of steel, slabs are furnace-heated to 1400°C prior to rolling, and rolled stock heat treatment is performed at temperatures up to 1250°C. Thus unless the production arrangement is altered, a nuclear reactor would have to heat the working medium -- reducing gas or metal billet, to extremely high temperatures.

In principle a nuclear reactor can produce such temperatures, but at the present time there are no heat-resistant structural materials which could provide efficient operation of a nuclear reactor incorporated into a metallurgical cycle.

The fact is that in removing heat from the reactor core, we contaminate the heat-transfer agent, making it radioactive. Transfer of heat from the primary to the secondary circuit is most efficiently accomplished via metal heat exchangers, which should be made of heat-resistant and corrosion-resistant alloys. Their operating efficiency in conditions of simultaneous effect of a mechanical load, temperature, environment and radiation determines the maximum temperature for which a heat exchanger can be designed. Proceeding from the level of properties achieved at the present time by heat-resistant alloys, this temperature is about 1000-1200°C. This means that the employment of nuclear energy in iron production requires a basic process change. Implementation of the idea of direct reduction with utilization of hydrogen as reducing agent in place of the carbon contained in fossil fuels, constitutes such a fundamental solution to metallurgical problems. Why hydrogen? Hydrogen can be obtained in large quantities in equipment utilizing the electric power and thermal energy of nuclear generating units.

Reactors of the VVER [Water-Moderated Water-Cooled]-RBMK [expansion unknown] have proven effective as reliable power generating equipment. These reactors can be employed to provide energy to the metallurgical processes of obtaining iron and iron-base alloys. Estimates indicate that the energy efficiency of a metallurgical complex based on type VVER-RBMK reactors is no worse than that of the existing method of producing iron based on the blast-furnace process. Total elimination of coke, natural gas or other fossil fuel is achieved, however, in a nuclear metallurgical complex (YaMK), by building a unit to produce "synthetic" reducing gas, in which hydrogen will be obtained from water. Utilization of hydrogen as reducing agent also makes it possible to develop a waste-free production process. These fundamental qualitative differences between YaMK and traditional metallurgical complexes make YaMK a prototype of future metallurgy.

Reduction of ferric oxide on a commercial scale can be achieved with three fundamentally different process variants.

High-temperature reduction. This process takes place at a temperature of greater than 1600°C. At this temperature iron and iron alloys are in a liquid state. The principal piece of metallurgical equipment is a jet-plasma reactor for heating the reducing gas, in combination with a melting furnace. Hydrogen or hydrogen mixed with carbon monoxide can serve as reducing agents. A jet-plasma reactor can heat such a reducing-agent gas to a temperature of 2000-2500°C.

Ferric oxide will reduce as a result of this single-stage process and will be carried away with the gas stream, in the form of a rain of liquid droplets heated to a temperature of more than 1500°C, into a plasma furnace, where all operations to obtain alloy steel can be performed. With this arrangement, the high temperature is obtained not in the nuclear reactor proper but in a plasmotron operating on electric power generated at a nuclear power station.

It would seem that this high-temperature arrangement is indifferent to source of electric power and should be independent of the type of fuel (nuclear or fossil) utilized at the power plant. However, the combination of thermal electric power plant, obtaining and heating reducing agents, and the metallurgical process merely transfers fuel and ecological problems from the metallurgical to the power engineering sphere, without solving them. Replacement of a thermal electric power plant by a nuclear power plant in this combination totally eliminates the necessity of consuming organic fuel to produce metal.

The advantages of the plasma technique of producing high-temperature reducing-agent gas are due to the exceptionally high output capacity of the plasma process. With this method of heating the reducing-agent gas, output of the reducing unit is two orders of magnitude greater than that of existing metallurgical equipment.

Medium-temperature reduction. The temperature of this process is 850-900°C. Hydrogen or a mixture of hydrogen with carbon monoxide can be used as reducing agent. Iron is in a solid state at this temperature, and sponge iron will be the reduction product. With medium-temperature reduction, in contrast to the high-temperature process, a large percentage of the gas can be heated to 250-300°C in a heat exchanger, circulating in the primary circuit of which is steam heated in a nuclear power reactor. Only one third of the gas is heated to 2000°C in a plasmotron, powered by electricity generated by the nuclear reactor. The low-temperature and high-temperature gases mix, and are fed at a temperature of 850-900°C into a special shaft furnace, where the ferric oxide is reduced and sponge iron is formed. The sponge iron can go either into a steelmaking furnace or can be utilized as a separate product for requirements of the machine building industry.

Low-temperature reduction. Process temperature ranges 450-600°C. The bulk of the reducing-agent gas required for this process can be heated by heat obtained in a nuclear generating unit. The process of low-temperature reduction of ferric oxide is of particular interest, since it has not yet been accomplished in industry even experimentally. Nevertheless it follows from the Fe-O-C-H equilibrium diagram that at temperatures below 810°C there occurs a multistage process of reduction of iron oxides. The multistage nature of the process is described at temperatures below 570°C by the following reactions:

$$Fe_2O_3 + \frac{1}{3}H_2 \rightarrow Fe_3O_4 + \frac{1}{3}H_2O$$

$$Fe_2O_3 + \frac{1}{3}CO \rightarrow Fe_3O_4 + \frac{1}{3}CO_2$$

$$\frac{2}{3}Fe_3O_4 + \frac{8}{3}H_2 \rightarrow 2Fe + \frac{8}{3}H_2O$$

$$\frac{2}{3}Fe_3O_4 + \frac{8}{3}CO \rightarrow 2Fe + \frac{8}{3}CO_2$$

CO has a thermodynamic advantage over H_2.

It is very important for the ecology that water and carbon dioxide are process end products in addition to iron. The water can be utilized to obtain hydrogen and oxygen. Thus fundamental prerequisites are created for establishing a closed-cycle process of direction reduction of iron, when for the first time we do not need to take oxygen from the air to obtain iron.

The principal piece of metallurgical equipment for reducing iron oxides is the jet reactor, just as with the high-temperature process. Finely dispersed oxides or chlorides of iron constitute the initial raw material for the reduction process. Chlorides of iron can be obtained in iron ore concentration cycles with utilization of nuclear heat via a heat exchanger. One feature of this process is the fact that with the chloride process low-grade ores and various metallurgical production waste materials can be utilized as raw material subjected to concentration. With the chloride process hydrogen is the principal reducing agent.

Pure ultradispersed iron powder is the principal product of low-temperature jet reduction. This powder can be used in cermet processes, can be remelted in metallurgical equipment, can be cold-rolled into a finished product or converted into iron pentacarbonyl, subsequently obtaining highly-pure iron. Reducing agent production is a key item of any metallurgical complex. Hydrogen is the principal reducing agent in a nuclear metallurgical complex. Water, not a fossil fuel, serves as the initial product for producing hydrogen. YaMK can be supplied with hydrogen in two ways: electrolysis of water, and its chemical breakdown. Breaking down water with the reaction $H_2O+CO=CO_2+H_2\uparrow$ with subsequent regeneration of CO_2 into CO and return of the monoxide into the chemical cycle may prove more economical. The hydrogen-producing stage of this process is well developed; we are familiar with catalysts for this stage, based on mixed iron-chromium or copper-zinc oxides for temperatures of 300-400 and 240-300°C respectively. There are no problems with equipment here. The stage of regeneration of carbon dioxide into monoxide requires solving a number of new problems, connected chiefly with the problem of effective and efficient separation of the mixture of active gases.

One's attention is drawn by the following process features, which are extremely important for ecology: CO, a poisonous gas, is not discharged into the atmosphere but circulates in a closed loop; the gas mixtures employed in the process are extremely simple and contain no high-molecular hydrocarbon compounds. A second interesting feature of the process is the fact that sulfur, phosphorus and other impurities get into the reduced iron only from the ore, while in the blast-furnace process metal is contaminated to a significant degree by sulfur contained in the coke.

Preliminary estimates based on a consolidated experiment performed at the Tulachermet Association indicate that we can obtain iron of the following composition, percentage by weight, with the above-described new process, employing hydrogen reduction: $C \leqslant 0.01$; $S \leqslant 0.01$; $P \leqslant 0.005$; $Cu \leqslant 0.01$; $Si \leqslant 0.01$. Conventional steel contains more than five times as much carbon, five times as much sulfur, five times as much phosphorus, 30 tims as much silicon, and 40 times as much copper. Why do we need such pure iron produced on a commercial scale? First of all, due to increase in the quantity of automotive and electrical equipment industry scrap, the steel produced by industry is gradually becoming contaminated by lead, copper, tin and other elements which diminish the metal's potential. Secondly, experiments in deep removal of impurities from iron have indicated that its physical and mechanical properties can change radically. For example, iron of commercial-grade purity has a maximum magnetic permeability of 500 Gauss/Oersted, while high-purity iron, with an impurities content of less than 10^{-4} percent by weight, has made it possible to obtain a magnetic permeability of 100,000-300,000 Gauss/Oersted, and coercive force decreases thereby from 0.3-1.2 to 0.029. Temperature of transition to a brittle state during impact testing on iron drops by 70°C. The character and kinetics of phase transformations change sharply in alloy steels produced with high-purity iron. In pure steels and irons, quenched solid solution dissociation time increases severalfold, the martensitic transformation temperature shifts by 150-200°C, corrosion resistance increases from double to threefold, and the plasticity of the metal increases substantially, especially in a coarse-grained state.

Experiments conducted on a commerical scale at the Tulachermet Association indicated that steelmaking with a high purity charge decreases 10-fold the content of such impurities as arsenic and antimony; in experimental melts spectral analysis fails to reveal lead, zinc and other harmful elements. U10A simple carbon steel increases its durability as a pressworking tool double to threefold just by reducing the content of impurities.

A comparison of the properties of steel produced from high-purity iron with the properties of metal following various refining remelts indicates that steel obtained from a pure charge approximates in its properties metal produced by electroslag remelting. It following from this that direct-reduction iron should be utilized in producing steels the purity of which, as regards residual impurities, plays a determining role in the formation of process, mechanical and operating properties. These include high-strength martensitic-aging steels, heat-resistant steels, toolsteels, die-forging and high-purity steels for metal products. Increased service life of iron-base steels and alloys obtained from a high-purity charge also promises enormous savings in alloying elements -- nickel, cobalt, vanadium, tungsten, molybdenum, and others, which are becoming in increasingly short supply year by year.

In addition to obtaining high-purity iron, hydrogen reduction opens up extensive prospects for solving other problems of the metallurgical industry. We know that high-grade ores are becoming available in increasingly smaller quantities. Hydrogen reduction can play a decisive role in the commercial exploitation of low-grade ores, by hydrochloride treatment of such ores as well as waste material from metallurgical production, metalworking, and nonferrous metallurgy.

In light of this, a number of ore bodies in the Tula, Kerch', Krivoy Rog and Dnepropetrovsk areas can be considered promising for recovery of iron by means of thermochemical concentration with utilization of nuclear-generated heat. Meriting particular attention are roasted pyrite residues, ferrous metallurgical slimes and pickling solutions, which should also be utilized for recovery of iron.

A highly attractive idea for the future is development of a thermochemical cycle for obtaining metallurgical raw materials by means of sulfuric-acid treatment of iron-containing materials. This cycle presupposes amalgamating iron production with the production of sulfuric acid and ammonia.

Thus the creation of a nuclear metallurgical complex based on utilization of hydrogen as reducing agent will make it possible to accomplish a number of major tasks facing today's metallurgical industry. Experience in combining nuclear power with metallurgical technology will determine the most promising paths of development of metallurgy of the future.

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3024
CSO: 1842/168

VALUE OF BY-PRODUCT ORES

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 17 Jun 81 p 2

[Article by N. Glushkov: "The Value of By-Product Ores"]

> [Text] Last year the editors published a series of articles on the problems of the rational utilization of mineral and raw material resources. The authors, A. Mal'tsev--"Roasted Sand", V. Zubkov--"Why We Now Have Dumps", B. Laskorin, N. Mel'nikov, and L. Barskiy--"Generous Nature", and Yu. Chernegov--"At the Same Time and Advantageously", discussed the problem of effective extraction of minerals from the earth, and also their ingredients. Its practical solution touches upon problems of national economic planning, finances, price setting, accounting, and the design of mining enterprises.

The State Pricing Commission examined the problems discussed in these articles and considers them urgent. But it should be emphasized: in order to improve the thoroughness of earth resources utilization pricing offers no problem. Presently all operating enterprises which extract or process mineral resources have established wholesale prices for all valuable ingredients. Special attention was devoted to this question in reviewing the wholesale price lists.

In a joint letter Gosstroy SSSR, the State Commission on Mineral Reserves of the USSR Council of Ministers and the USSR State Pricing Commission authorized ministries and departments, while still at the reserve balance acquisition stage and when making projections for enterprises, to approach the USSR State Pricing Commission and the state pricing commissions of union republics with suggestions on setting wholesale prices for mineral ingredients for which prices have not been set. This is on the condition that the national economic necessity and expediency of their utilization have been proved. If the plan stipulates a workable technology for extracting a number of by-products then it is possible to calculate the expenditures and prices for these by-products, which allows one to accurately determine the expenditures and prices for the main ingredient.

The USSR State Pricing Commission is capable of making a quick decision on any specific and well founded recommendations of the ministries and departments for pricing the ingredients of raw materials. Even in the most complicated cases which require the participation of examining boards and specialists from various departments, this does not take more than two months. The USSR State Pricing Commission has already examined a number of recommendations of the ministries and made corresponding decisions.

However, as Messrs. Zubkov, Laskorin, Mel'nikov, and Barskiy correctly note, the current level of thoroughness of mineral resources' utilization is inadequate. A complete system of measures, and maybe a special purpose comprehensive program, is needed to raise it. The reserves are quite large. Thus, enterprises of the Ministry for Mineral Fertilizer Production do not extract the iron and other metals from the pyrite concentrates. They do not extract rare metals and other valuable ingredients during refinement of apatites. Cobalt contained in ores is thrown away as waste at the Sokolovsko-Sarbayskiy Mining and Enrichment Combine of the USSR Ministry of Ferrous Metallurgy. At the Kingiseppskiy phosphorite deposit the production of gravel as envisaged in the plan was not undertaken. At the neighboring deposit of oil shale in Estonia gravel is recovered from the same rocks in the strip mine, and there an extensive market has been made for it, all the way to Moskovskaya oblast'. That the solution of these problems does not depend on price is evident from the article by A. Mal'tsev "Roasted Sand": there is a price for the vanadium concentrate extracted from the iron ores of Kachkanarskiy deposit, but there is no orderly market, and the product is poled in a field, even though money has been spent on the means to produce it.

In the opinion of the USSR State Pricing Commission the main condition to be met in order to thoroughly utilize the earth's resources is the organization of efficient production at specific enterprises according to a specific technology. It is well known that any mining and metallurgical or mining and extracting enterprise begins with a plan. The plan assumes the availability of advanced and practical technology for the comprehensive utilization of raw material. Once the plan contains a solution to the engineering and technological problems and the enterprise is built with enough capacity to assure thorough utilization of raw materials, then one can turn to the problem of a price for all the ingredients. Yu. Chernegov deals with this problem in his article "At the Same Time and Advantageously", which mentions the need to use non-ore materials in every possible way.

It is necessary that USSR Gosplan and USSR Gosstroy, on whom the distribution of capital outlays, production planning and demand, and confirmation of plans depend, specifically solve the problems of developing integrated works on the base of mineral deposit exploitation without depending on their departmental affiliation. These solutions should be included in the new five-year plan.

The USSR State Pricing Commission thinks that the discussion on problems of the use of mineral resources organized by the newspaper "Sotsialisticheskaya Industriya" is quite valuable. The participation of ministries and departments in solving the problem and the coordination of their activities can speed up and provide good organization to the task of improving the effectiveness of the mineral raw material base of the country.

9424
CSO: 8144/1339

UDC 536.421.4:535.211

VAPORIZING MATTER BY LASER RADIATION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81
(manuscript received 10 Jul 79) pp 3-11

SAMOKHIN, A. A. and USPENSKIY, A. B., Moscow

[Abstract] Interaction of laser radiation and an absorbing condensate medium is considered, this interaction resulting in a transition of the condensate to the gaseous state with an attendant increase of its specific volume and thermal capacity. The analysis is based on the thermal model with surface evaporation with a simply connected phase boundary surface and one-dimensional kinetics of the phase transformation. The corresponding thermodynamic boundary-value problem of heat conduction is solved for the case of strongly absorbing substances such as metals, where the depth of radiation penetration is smaller than the characteristic depth of thermal influence, and the effect of the temperature dependence of the thermophysical properties on the transient stage of the evaporation process is evaluated for mercury (this effect being relatively weak in the case of copper and silver with a high absorption capacity already at temperatures much below the evaporation point). Refinements of that thermal model are required for high radiation intensity levels and, particularly, when the depth of radiation penetration becomes large so that energy is absorbed by the bulk of metal and surface evaporation is destabilized by relaxation of excess energy. The transient process becomes nonmonotonic, moreover, with pressure oscillations due to thermal expansion. In other experimental studies with microsecond radiation pulses from at CO_2 laser acting on the surface of water, the pressure variation with time during the transient period has been found to depend largely on the energy density at the surface. Figures 5; references 22: 20 Russian, 2 Western.
[154-2415]

UDC: 669.018.44:539.376

ESTIMATING AND PREDICTING CREEP OF METAL MATERIALS

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 81
(manuscript received 12 Aug 80) pp 38-45

KOVPAK, V. I., Institute of Strength Problems, Ukrainian Academy of Sciences, Kiev

[Abstract] A study is made of the results of a unique experiment on creep performed using specimens of chrome-nickel-molybdenum steel at 500°C, with an experimental duration of up to 100,000 hours. Analysis of the primary creep curve is presented for a material subjected to a stress of 160 MPa. It is noted that the deformation at which the third stage of creep arises at stresses of less than 160 MPa is less than 0.1%, although total deformation is always over 4%. The permissible deformation on the order of 1% or more thus always relates to the accelerated stage of creep. The problem of reliable determination of the area of avalanche creep thus becomes very important from the standpoint of optimal utilization of the service properties of materials, since most of the creep deformation for many materials develops in this area. Reliable description and prediction of creep requires unambiguous and reliable determination of the characteristic points on the creep curves such as the beginning of the accelerated stage and the beginning of the area of avalanche creep. It is most correct to evaluate the long term strength of materials up to the beginning of avalanche creep, when the materials still retain a structure similar to the initial state. Results of the extremely long term creep experiments here analyzed indicate that even for structurally stable materials there can be no single condition of similarity in all stages of creep. Reliable prediction of creep to the point of failure requires: testing at the operating temperature and at least two other higher temperatures over a limited test duration, to allow predictions to be made; determination of the point of beginning of the third stage, of avalanche creep and the corresponding similarity factors; use of temperature-time similarity to predict the time of beginning of these stages of creep and deformation for the stress levels in question; selection of a model creep curve at a higher temperature with statistical averaging based on the results of testing of several specimens. Figures 7; references 14: 11 Russian, 3 Western.
[138-6508]

UDC: 539.388.1

INFLUENCE OF TEMPERATURE ON CYCLICAL CREEP PROCESS OF HEAT RESISTANT ALLOYS WITH MULTICYCLE LOADING

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 81 (manuscript received 2 Apr 80) pp 17-23

GOLUB, V. P., Institute of Mechanics, Ukrainian Academy of Sciences, Kiev

[Abstract] The influence of temperature on cyclical creep was estimated by performing a cycle of experimental studies intended to produce equations describing cyclical creep deformation as a function of time for various temperatures. Heat resistant nickel-based alloys--EI867, EP109, VZhL12U and ZhS6U--were studied after typical heat treatment used in the manufacture of gas turbine motor parts. It is found that an increase in temperature results in an increase in cyclical creep deformation, both instantaneous and accumulated, and a decrease in time to failure. The components describing cyclical creep with constant and increasing rate increase more rapidly than the component describing unstable creep. Within the range of temperature studied, the process of cyclical creep is primarily controlled by stable creep. The principle of superposition of temperature and force effects is valid for the process of cyclical creep of refractory nickel-based alloys with multicylce asymmetrical loading. Figures 5; references 12: 10 Russian, 2 Western.
[138-6508]

UDC 546.47'221+546.47'231+546.48'221

OXYGEN CONTENT IN ZnSe, ZnS and CdS CRYSTALS GROWN FROM MELT

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 17, No 7, Jul 81 (manuscript received 5 May 80) pp 1159-1161

ZUYEV, A. P., KULAKOV, M. P., FADEYEV, A. V. and KIREYKO, V. V., Institute of Solid-State Physics, USSR Academy of Sciences

[Abstract] Direct measurements were made of the oxygen content in crystals of $A^{II}B^{VI}$ semiconductor compounds: ZnS, ZnSe, and CdS. Crystals were grown by the Bridgman-Stockbarger method in graphite crucibles, from powder with a total impurity content not exceeding 10^{-3} wt.%. The specimens were prepared in the form of cylinders 0.03 m in diameter and 0.01 m high, their surface polished first mechanically and then chemically. They were bombarded with fast (14 MeV) neutrons from a D-T reaction in an NG-105M neutron generator. The induced oxygen activity was measured with an NaI(Tl) scintillation detector. A standard specimen of titanium with 0.06 or 0.11 wt.% O served as a reference for calculating the oxygen content. The latter was thus found to correspond to $(1-2)\cdot 10^{-2}$ mol.% oxide in ZnS and CdS, $(4-5)\cdot 10^{-2}$ mol.% oxide in ZnSe. The maximum solubility of ZnO in ZnSe is 2 mol.% at 1770°K and decreases with decreasing temperature, which causes precipitation of the second phase and consequently opacity of crystals. References 8: all Russian.
[162-2415]

UDC 541.67

HALL PHOTOEFFECT IN ZnS AND ZnSe CRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 17, No 6, Jul 81 (manuscript received 31 Mar 80) pp 1162-1165

ANDREYEV, A. A., BORISENKO, N. D., KOVALENKO, A. V. and YAKUNIN, A. Ya.,
Dnepropetrovsk State University

[Abstract] Electrical self-compensation makes it difficult to change the conductivity of ZnS and ZnSe single crystals from n-type to p-type. A study was made to determine the sign of charge carriers in such single crystals grown from a melt under an argon pressure. The spectrum of the Hall photoemf was measured with a DMR-4 monochromator, a DKSHs-1000 xenon lamp serving as the source of radiation. Sharp peaks have been established at approximately 3.6 eV for ZnS and 2.7 eV for ZnSe. Specimens of ZnSe were used for determining the dependence of the dark Hall emf and the electrical resistivity on the annealing temperature (annealing for 5 hrs in a Zn melt or in an Se melt), the results indicating a dependence of the conductivity on the stoichiometry. Annealing in a zinc melt causes filling of the zinc vacancies and implantation of excess zinc so that fine donor levels appear which reduce the electrical resistivity and produce n-type conductivity. Annealing in a selenium melt causes filling of any selenium vacancies and implantation of excess selenium so that uncompensated acceptor levels may appear and p-type conductivity become stabilized. Figures 2; references 21: 10 Russian, 11 Western.
[162-2415]

UDC: 678.011

RELAXATION NATURE OF THERMAL DESTRUCTION PROCESS OF POLYMERS AND INFLUENCE OF HEAT TREATMENT ON THEIR PROPERTIES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 6, 1981
(manuscript received 16 Oct 80) pp 1363-1366

ZADORINA, Ye. N., VISHNEVSKIY, G. Ye. and ZELENEV, Yu. V., Moscow Aviation
Institute imeni Sergo Ordzhonikidze, Moscow Textile Institute

[Abstract] Studies of the molecular mobility of various types of polymers indicate that a single-component polymer can be considered a complex system consisting of several weakly interconnected subsystems: the set of elements of the supermolecular structures, macromolecules of various lengths, free and bonded segments, various atomic groups, electron and nuclear spins, and various quasi-particles. The heating rate influences various parameters of the process of thermal destruction for all polymers. Approaching the thermal destruction of polymers as a relaxation process leads to the introduction of a new quantity, the relaxation time of the process. The relaxation approach to this process has allowed a

method to be suggested for predicting the thermal stability of polymers when rapidly heated. An equation is presented for the relationship between the temperature at which thermal destruction begins and the heating rate. The process is found to be a relaxation process related to the mobility of supermolecular structures. A "fork" rule is developed to relate the influence of thermal prehistory to the structure and physical properties of various types of polymers subject to heat treatment. Figures 2; references 10: 9 Russian, 1 Western.
[139-6508]

UDC: 669.295'71

DISSOLUTION OF TITANIUM IN LIQUID ALUMINUM KINETICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 81 (manuscript received 11 Jul 79) pp 25-29

YEREMENKO, V. N., NATANZON, Ya. V., TITOV, V. P., NERUBASHCHENKO, V. V. and KRYMOV, A. P., Kiev

[Abstract] The kinetics of dissolution of titanium in liquid aluminum were studied in the 675-900°C temperature interval at speeds of rotation of the disk specimen of 6.61 to 36.80 rad/s. High purity aluminum and iodide titanium were used. The content of impurities in the titanium did not exceed the following percentages: Mg 0.02, Si 0.02, Al 0.02, Fe 0.06, Ni 0.03, Cr 0.02, Mn $8\cdot10^{-3}$, 0-0.1, N 0.03, C 0.06, Pb $1\cdot10^{-4}$, Sn $1\cdot10^{-4}$. The iodide titanium was remelted in an electric arc furnace and poured into a chill mold to produce fine-grained titanium. The specimens were then vacuum annealed at $3-4\cdot10^{-5}$ mm Hg at 900°C for 1 hour. The curves of the concentration of titanium as a function of time of dissolution are linear in the 700 to 900°C temperature interval in coordinates of $C_n/(C_{n-c})-S\tau/V$, indicating that the process of dissolution follows the Nernst rule. Dissolution rate constants are also presented. The dissolution of titanium in liquid aluminum is found to occur in the diffusion mode. Figures 5; references 7: 5 Russian, 2 Western.
[144-6508]

UDC 546.824.21

PHASE COMPOSITION OF ELECTRIC EXPLOSION PRODUCTS IN OXYGEN-RICH CUBIC TiC_xO_y AND $TiC_xO_yH_m$ PHASES

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 17, No 7, Jul 81 (manuscript received 27 Feb 80) pp 1218-1222

PAVLOV, I. Ye., Design-Engineering Office of Electrohydraulics, UkSSR Academy of Sciences

[Abstract] A phase analysis was made of products of electric explosion in oxygen-rich cubic TiC_xO_y and $TiC_xO_yH_m$ phases. Specimens of TiC_xO_y phases had been synthesized under vacuum ($1.3 \cdot 10^{-2}$ - $1.3 \cdot 10^{-3}$ Pa) at 1773°K, with their carbon and oxygen content monitored with a Coulomatic instrument. Specimens of $TiC_xO_yH_m$ phases had been prepared by impregnation of the TiC_xO_y phases with hydrogen at 873-1073°K in a Sieverts apparatus. Electric explosion was effected in water, in an electrohydraulic apparatus with a 6 μF - 1.5 μH discharge circuit. The data reveal some difficulties in the synthesis of such titanium oxycarbides, mainly due to their instability under the given process conditions. Electric explosion, characterized by high pressures and temperatures, causes oxygen-rich $TiC_xO_yH_m$ phases to split principally into two cubic phases and Ti_2O_y. Electric explosion in a mechanical mixture of $TiC_{0.97}$ and $TiO_{0.8}$ combining into $TiC_{0.51}O_{0.39}$ produces an oxygen-poor oxycarbide with small amounts of TiO_y and Ti_2O_3.
References 12: all Russian.
[162-2415]

UDC 546.824-31+546.65'643-31'763-31

ELECTRICAL CONDUCTIVITY OF TITANIUM DIOXIDE AND OF CHROMITES OF YTTRIUM AND RARE-EARTH ELEMENTS ON SUBSTRATE AT HIGH TEMPERATURES

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 17, No 7, Jul 81 (manuscript received 7 Jul 80) pp 1253-1255

POVOLOTSKIY, D. Ya., TOKOVOY, O. K., FEDULOV, A. P. and NEUYMIN, A. D., Chelyabinsk Polytechnic Institute, Institute of Electrochemistry, Ural Science Center, USSR Academy of Sciences

[Abstract] The electrical conductivity of chromites of some rare-earth elements (R = Y, La, Sm, Eu, Gd) with an admixture of calcium oxide ($0.5\ CrO_{1.5} + 0.4\ RO_{1.5} + 0.1\ CaO$) as well as of titanium dioxide in solid solution (pure or with admixtures of niobium oxide) was measured at temperatures from 1200 to 1650°C in an electrical-resistance graphite furnace. The electrodes had been prepared from extra-pure powders of the respective materials by proper mixing, baking in air, pressing into platelets, coating with a benzene solution of platinum powder and caoutchouc, then heating in air at 1550°C for 2 hrs. The electrical resistivity was measured by the contact method with an R58 a.c. bridge at 3000 Hz. Calculations were made

of the coefficients in the equations describing the temperature dependence of the electrical conductivity and, using the $\sigma = Ae^{-E/2kT}$ relation, also the conductivity activation energy. The results indicate that these chromites of rare-earth elements with CaO as well as TiO_2 + 5 mol.% Nb_2O_5 are very suitable as anodes in oxygen concentration cells for deoxidation of steel. Figures 1; references 6: all Russian.
[162-2415]

UDC 546.824'261+546.623-31

MICROHARDNESS AND MICROBRITTLENESS OF TiC-Al_2O_3 CONDENSATES

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 17, No 7, Jul 81 (manuscript received 27 May 80) p 1309

MOVCHAN, B. A. and GRECHANYUK, N. I., Institute of Electric Welding
imeni Ye. O. Paton, UkSSR Academy of Sciences

[Abstract] Condensates of the TiC-Al_2O_3 2-phase diffusion-ceramic system were studied to determine the dependence of their microhardness (P = 50 g) and critical indenter load corresponding to the beginning of brittle fracture on the Al_2O_3 content. The specimens were produced by simultaneous electron-beam evaporation of the two components from separate sources, which made it possible to achieve a uniform gradient of Al_2O_3 concentration. The vapor phase was deposited on substrates at 1273°K and 70-100-μm-thick films of the condensate were allowed to build up. The curves plotted from test data reveal a sharp dip of the microhardness and a sharp peak of the critical load corresponding to 8 vol.% Al_2O_3. The condition of maximum plasticity (resistance to brittle fracture) had been demonstrated earlier to correspond to a mean free path between Al_2O_3 particles equal to the mean diameter of TiC grains, this condition being satisfied here with Al_2O_3 particles of the 0.1 μm size and TiC grains of the 0.8-1 μm size. Figures 1; references 4: all Russian.
[162-2415]

UDC 621.793.7

ANOMALIES IN VACUUM-CONDENSATION PROCESS OF PRODUCING METAL AND ALLOY FILMS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81
(manuscript received 9 Oct 78) pp 69-72

ULANOVSKIY, Ya. B, ZHIL'TSOV, Ye. S. and ZHURAVEL', A. P., Moscow

[Abstract] Producing metal and alloy films by the vacuum-condensation process for quality studies involves evaporation of the bulk material under vacuum with

subsequent condensation of the vapor on a preheated substrate and then separating the condensate film from that substrate prior to testing it. The effect of separation from the substrate on the mechanical properties of such films was studied in the case of the VT6 titanium alloy (Ti + 6% Al + 4% V), 40-μm-thick films of this material having been deposited on 50-μm-thick M1 copper substrates (later etched away with an aqueous 15% HNO_3 solution) and on 50-μm-thick Kh18N9T steel substrates (through an $MgCl_2$ interlayer, later peeled off mechanically). In the first case diffusion of copper into the condensate film and formation of intermetallic compounds were found to alter the mechanical properties of the film, causing embrittlement and thus offsetting an increase of plasticity due to stress relief. This effect can be avoided by addition of an antiadhesive interlayer or, if this is not feasible, lowering the temperature of the etchaway substrate to the minimum possible or using a substrate material with a low coefficient of substrate-condensate interdiffusion. Figures 3; references 11: 8 Russian, 3 Western.
[154-2415]

UDC 669.554:669.715':536.421.4

STRUCTURAL ANOMALIES IN MATERIALS BASED ON ZINC-LEAD AND ALUMINUM-LEAD SYSTEMS PRODUCED UNDER CONDITIONS OF QUASI-WEIGHTLESSNESS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May-Jun 81 (manuscript received 6 Aug 79) pp 47-52

ABRAMOV, O. V., GEL'FGAT, Yu. M., SEMIN, S. I., SORKIN, M. Z. and CHASHECHKINA, Zh. Yu., Moscow

[Abstract] Producing such pseudoalloys as zinc-lead and aluminum-lead "frozen emulsions" in orbiting space stations beyond the earth's gravitational field has been considered as a way to avoid stratification, in the liquid state, of components with widely different densities. The distribution of components in such a pseudoalloy can be controlled magnetohydrodynamically, moreover, if their electrical conductivities also differ. Here a study was made to determine the structural anomalies in thus produced pseudoalloys, with conditions of weightlessness simulated by means of electric and magnetic fields. The apparatus included a melting pot, an electric heater system, a cooler with a water supply, and an electromagnet and a pair of electrodes. Specimens of Zn+ 8,15,22,30 wt.% Pb and Al+ 13,15,20 wt.% Pb were produced by this method with both the heating rate and the cooling rate controlled in the process: the Zn-Pb melts were heated to 850° and cooled at 15-20 or 100-120°C/min, the Al-Pb melts were heated to 1270°C and cooled at approximately 40°C/min. Micro- and macrostructural examination under a Neophot-2 microscope and with a JXA-5 analyzer, after chemical polishing of surfaces and subsequent etching with aqueous 25% NaOH or 20% NHO_3 solutions, revealed which metallurgical process conditions will yield a sufficiently uniform distribution of fine-disperse inclusions of the second phase (excess components immiscible in the liquid state) under action of electric and magnetic forces. The authors thank I. K. Al'yen and F. G. San'kov for performing the quantitative

microstructural analysis of specimens with the aid of the "Rastr" automatic television-type instrument (developed at the Institute of Electronics and Computer Engineering, LatSSR Academy of Sciences). Figures 5; references 4: all Russian.
[154-2415]

UDC: 669.295:669.14:686.4

INTERNAL STRESSES IN TITANIUM CONDENSATES

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, Jul 81 pp 52-54

KHARITONOVA, L. D., MASLOVSKIY, V. A. and SMIRNOVA, I. N.,
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[Abstract] Internal stresses in titanium condensates precipitated on substrates of low-carbon steel and the bonding strength between the condensate and substrate were studied as a function of the condition of the surface and the difference in coefficients of thermal expansion of condensate and substrate. The titanium was evaporated by means of an electron gun from a water cooled copper crucible. The condensation rate was 0.3 μm/min, condensation time 30 minutes. Titanium was condensed onto substrates of 08kp steel, VTL-0 titanium and 12Kh18N9T stainless steel. Macrostresses in the condensates were determined by an x-ray method based on measurement of the lattice period. Six series of experiments were performed. In series 1 and 6, the 08kp steel and titanium substrates were vacuum annealed at 600°C for 5 minutes to remove physically and chemically sorbed contaminants from the surface. In the other series, oxide or salt layers were present on the surface. It was found that internal stresses had no influence on the bond strength under the conditions studied, though some influence is theoretically possible. A change in the direction of stress in the condensate after dissolution of the substrate indicates that internal stresses are significantly relaxed by plastic deformation of the condensate, not resulting in the formation of cracks. When titanium was condensed onto substrates covered with a layer of MgF_2, the bond strength was less with higher coefficient of thermal expansion of the material of the condensate and substrate. References 4: all Russian.
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